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AEGIS and Ship Self- Defense System (SSDS) Platforms: Using KVA Analysis, Risk Simulation and Strategic Real Options to Assess Operational Effectiveness

30 September 2006

by

Captain Joseph Uchytil, USMC, Dr. Thomas Housel, Sandra Hom, Dr. Johnathan Mun and Eric Tarantino, Naval Postgraduate School

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Abstract

Modern, analytical tools are critical to understand the impact of open architecture technology and open business models on naval warfighting processes and procedures. These tools must measure the operational value of a system from an end-user, warfighter perspective, identify areas of deficiencies in capabilities, and flag areas for potential acquisitions. One advantage of examining open architected system upgrade options from a warfighter perspective is that the new systems can be integrated with reengineered processes more easily leading to improved process performance. This perspective, using OA to upgrade existing IWS systems, ensures that upgrades will lead to improved warfighting capabilities. Traditional measurement tools used for cost analysis cannot calculate the *total value* of upgrading a system to support an improved warfighting capability, particularly the improved operational value resulting from reengineering of warfighting processes.

The Knowledge Value Added/Real Options (KVA+RO) Valuation Framework is a tool designed to assist decision-makers in making technology acquisitions. This paper describes research using the KVA+RO framework for estimating return on investment, in an open architecture approach, to upgrading and/or replacing aging IWS AEGIS and SSDS systems. The results of the research indicated that using the open architecture (OA)model, in combination with the "leave and layer" approach, was approximately five times more valuable than the current proprietary approach to system replacement and was approximately twice as valuable as a complete retrofit and replace strategy. "Leave and layer" provided the highest return on investment for replacing the AEGIS system with the lowest risk. The ultimate success of the OA approach is dependent on the ability of the multiple parties to system development and deployment to collaborate. Collaboration, along with the tools that facilitate collaboration, is critical to the success of any of the OA approaches.

Keywords: Return on Investment, Real Options, AEGIS, SSDS, Integrated Risk Management

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Tom Housel specializes in valuing intellectual capital and knowledge value measurement. He is currently a tenured Full Professor for the Information Sciences (Systems) Department. He won the prestigious Society for Information Management award for best paper in the field in 1986. His work on measuring the value of intellectual capital has been featured in a *Fortune* cover story (October 3, 1994) and Investor's Business Daily, numerous books, professional periodicals, and academic journals (most recently in the *Journal of Intellectual Capital,* 2005, Vol. 2).

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I. Executive Summary

The US Navy (Navy) is transforming traditional business practices through Naval Open Architecture (Naval OA). Naval OA, a multi-faceted, enterprise-wide business model and product-line strategy leverages "open" computer design principles and architectures. It expands the technological open architecture (OA) model and taps into a multiple-developer network to deliver cost-effective, innovative, and rapid/spiral acquisition capabilities. In the migration to an OA business model, billions of dollars in software and hardware development expenditures, along with subsequent maintenance costs, are at stake.

PEO IWS tasked a research team from the Naval Postgraduate School (NPS) to develop a methodology for estimating return on investment (ROI) using an OA approach to upgrading and/or replacing the aging Integrated Weapons Systems (IWS) AEGIS and SSDS systems. The methodology also had to be capable of estimating total value of strategic alternative options for replacing existing AEGIS functionality.

Approaching the project from a customer-based, warfighter perspective, the NPS team applied the Knowledge Value Added/Real Options (KVA+RO) valuation/risk portfolio management framework to reengineering situational awareness (SA) procedures used in the AEGIS and SSDS platforms.[1] Track management sub-processes used in SA procedures were analyzed through the KVA process reengineering methodology under "As Is," "To Be," "Radical 1," and Radical 2" scenarios. ROI metrics on individual sub-processes and watch stations for AEGIS and SSDS were generated through KVA, with a particular focus on systems interoperability. ROI estimates reached as high as 404% for AEGIS and 399% for SSDS.

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[1] Although the total functionalities of AEGIS and SSDS IWS systems are so broad, we focused on situational awareness because it is the most promising area for upgrading and reengineering.

Real options analysis was then performed to determine the prospective value of upgrading the AEGIS IWS over a nine-year period from KVA data inputs. Three options of “Strategy A: As Is” (i.e., maintain the existing proprietary approach), “Strategy B: DDX OA—Develop and Retrofit” (i.e., develop a complete system using an OA approach and replace the existing AEGIS system), and “Strategy C: Aegis OA—Leave and Layer” (i.e., use an OA approach and replace AEGIS modules over time) represent potential system development and deplolyment strategies; each a unique path with risks and benefits. Real Options values ranged from $12 billion to $58.8 billion for the strategic choices.

A. The KVA+RO Framework

KVA+RO is a comprehensive measurement process and an integrated tool set that defines, measures and evaluates the total value of given IWS acquisitions. It captures data across a spectrum of organizations to compare returns on investments, outputs, processes, capabilities, risks, strategic alternatives, costs, and value (i.e., comparable revenue). KVA+RO analytically quantifies uncertainty and risks elements inherent in predicting the future, includes ways to mitigate these risks through strategic options with analysis of alternatives, and by analytically developing and allocating budgets to optimize project portfolios.

1. Knowledge-based Metrics: Knowledge Value Added (KVA)

KVA measures the value provided by human capital assets and IT assets by an organization, process or function at the sub-process level. Using a “market comparables” valuation technique, it monetizes the outputs of all assets, including intangible knowledge assets. Using market comparables provides a means for valuing the outputs of warfighting processes in the common units of money. This, in turn, makes it possible to use powerful financial metrics in forecasting the value of various strategic options for replacing aging IWS systems.

Capturing the value embedded in an organization’s core processes, employees and IT enables the actual cost and revenue of a product or service to be calculated. Analyses like ROI on individual projects, programs, processes and sub-processes within a portfolio of IT acquisitions can be derived through the KVA methodology.

2. Risk Analysis: Real Options (RO)

Potential strategic investments can then be evaluated with real options analysis based on KVA data. The analysis applied is a robust and analytical process incorporating the risk identification (applying various sensitivity techniques), risk quantification (applying Monte Carlo simulation), risk valuation (applying real options analysis), risk mitigation (utilizing real options framing), and risk diversification (employing analytical portfolio optimization).

3. Study Results and Recommendations Summary

The results of our analysis include:

- ***The KVA+RO valuation framework, a viable methodology for estimating ROIs and projecting valuation of acquisition options, should be used across the board.*** Several Department of Defense projects are implementing the framework. The methodology also supports the CNO's recent directive of accelerating adoption of open-business models and providing a methodology to assess the business risks and benefits of various OA-based acquisition strategies.

- ***Upgrading existing IWS functionality to support reengineering elements of existing track-management process appears beneficial.*** ROIs ranged from 212% to 404% for the AEGIS platform and ROIs for the SSDS platform were also significant. ROI results are shown in Figures 1 and 2.[2] In addition, Tables 1 and 2 provide a detailed analysis of the ROIs for reengineering the track management

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[2] Radical 1 scenario assumes the improvements of the "To Be" scenario while the Radical 2 scenario assumes cumulative improvements from all three scenarios.

process. Table 3 summarizes the reengineered processes and subsequent benefits. The results are based on the assumption that the IWS systems could be developed within an OA framework to support the reengineered process designs.

Figure 1. KVA Results: AEGIS ROI Estimates

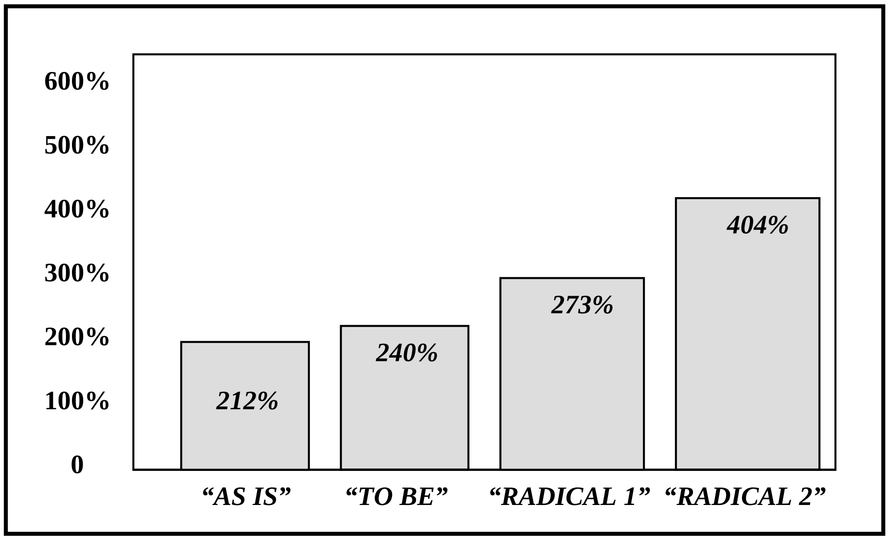
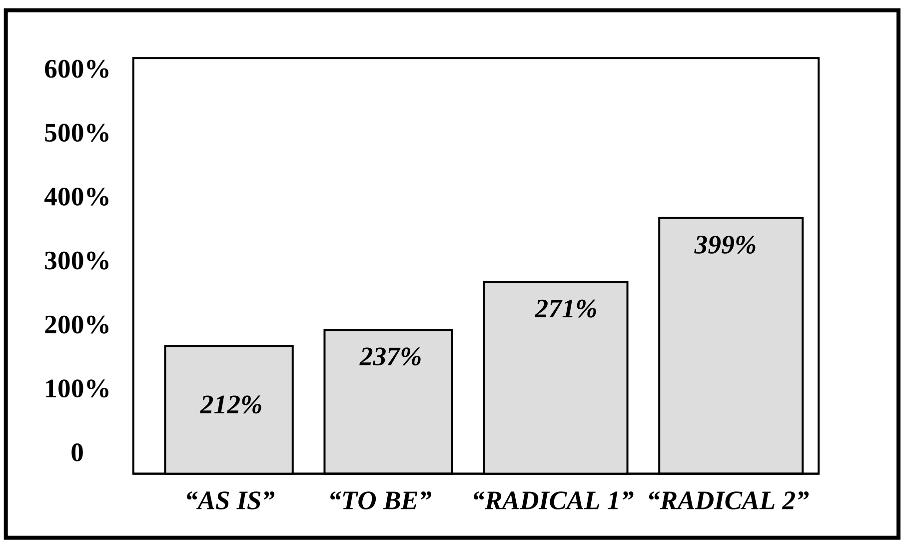


Figure 2. KVA Results: SSDS ROI Estimates



Tables 1 and 2 are more detailed results for ROI analysis for "As Is" and the other three increasingly automated scenarios.

Table 1. Detailed ROI Estimates for AEGIS

	AS IS	TO BE	RAD 1	RAD 2
CORRELATE				
Obtain Link Information	3421%	3307%	3063%	2633%
Identify "Same Contact, Multiple Track"	-91%	-91%	2061%	1756%
Verify Other Track Sources	-95%	-95%	-95%	-96%
Correlate sub-total	***1184%***	***1141%***	***1506%***	***1296%***
TRACK				
Monitor Suspect Tracks	-98%	-99%	-99%	-99%
Update Tracks	-97%	-97%	361%	310%
Update GCCS-M	-97%	91%	84%	69%
Track sub-total	***-98%***	***-94%***	***-58%***	***-64%***
IDENTIFY				
Verify IFF signal	802%	769%	706%	607%
Verify EW emissions	-91%	-91%	-92%	509%
Verify Point of Origin	-98%	4121%	3821%	3332%
Match Against ATO	-98%	4206%	3890%	3382%
Match Against CommAir Profile	863%	835%	763%	643%
Match Against Intel Information	-97%	-97%	-97%	3814%
Examine Kinematic Data	-96%	-96%	-97%	-97%
Obtain Visual ID	-100%	-100%	-100%	-100%
Conduct Verbal Query	-99%	-99%	-99%	-99%
Identify sub-total	***8%***	***60%***	***50%***	***326%***
RELAY				
Send Over Links	-87%	-88%	-89%	-90%
Discuss Picture with Battle Force Units	-98%	-99%	-99%	-99%
Relay sub-total	***-97%***	***-98%***	***-98%***	***-99%***
Totals	**212%**	**240%**	**273%**	**404%**

Table 2. Detailed ROI Estimates for SSDS

	AS IS	TO BE	RAD 1	RAD 2
CORRELATE				
Obtain Link Information	3393%	3280%	3026%	2598%
Identify "Same Contact, Multiple Track"	-91%	-91%	2530%	2158%
Verify Other Track Sources	-95%	-95%	-96%	-96%
Correlate sub-total	***1174%***	***1131%***	***1512%***	***1301%***
TRACK				
Monitor Suspect Tracks	-98%	-99%	-99%	-99%
Update Tracks	-96%	-97%	546%	475%
Update GCCS-M	-98%	14%	10%	1%
Track sub-total	***-98%***	***-96%***	***-53%***	***-60%***
IDENTIFY				
Verify IFF signal	790%	757%	692%	595%
Verify EW emissions	-90%	-91%	-91%	474%
Verify Point of Origin	-98%	3689%	3405%	2967%
Match Against ATO	-98%	3813%	3510%	3049%
Match Against CommAir Profile	926%	896%	816%	688%
Match Against Intel Information	-97%	-97%	-97%	3688%
Examine Kinematic Data	-96%	-96%	-96%	-96%
Obtain Visual ID	-100%	-100%	-100%	-100%
Conduct Verbal Query	-99%	-99%	-99%	-99%
Identify sub-total	***12%***	***59%***	***48%***	***316%***
RELAY				
Send Over Links	-82%	-83%	-84%	-86%
Discuss Picture with Battle Force Units	-99%	-99%	-99%	-99%
Relay sub-total	***-97%***	***-98%***	***-98%***	***-98%***
Totals	**212%**	**237%**	**271%**	**399%**

Table 3 discusses the potential impact of an OA approach on AEGIS and SSDS.

Table 3. Potential Benefits of OA Combined with Reengineering of Track Management Operations

	"As Is"	"To Be"	"Radical 1"	"Radical 2"
	None	Limited re-engineering	Significant re-engineering	Substantial re-engineering
Technology Impact	**None**	• Info provided in ATO could be upgraded into AEGIS, reducing manpower requirements. • Enables greater sensor and data integration, providing enhanced correlation in pinpointing origin of aircraft or ship.	• Streamlined system automatically updates tracks. • Increased information-sharing and collaborative technology allows for automatic correction of multiple tracks per target. • Continuously updates tracks, allowing for pinpoint accuracy. • Collaborative technology minimizes possibility of multiple tracking of targets. • Includes changes from "To Be"	• Collaborative technology automatically updates ship's systems with Intel information. • Electronic communication of data from EW to CIC personnel facilitates COTS-based environment that easily upgrades to accommodate greater processor speeds. • Greatly enhances CIC efficiency through more timely SA. • Includes changes from "To Be" and "Radical 1."
Potential Benefits*	------	• Reduces maintenance costs. • Frees watch-standers to perform other tasks while providing faster data flow.	• Increases accuracy of tracking targets.	• Substantial re-engineering leads to drastic reduction in watch-stander work time, greatly reducing human error and further decreasing maintenance costs.

- ***Strategy C: Leave and Layer is the most promising strategy with lowest total costs.*** It has the highest potential rate of return with a valuation of $58.8 billion and 4.9 times the potential return than Strategy A. Strategy B has a valuation of $23.2 billion, while Strategy A has the lowest valuation at $12 billion.

Table 4. Real Options Valuation Results: Strategies A-C

	Strategy A	Strategy B	Strategy C
STRATEGIC OPTION	"As Is"	DDX OA "Develop and Retrofit"	AEGIS OA "Leave & Layer"
Net Present Value	$12.00B	$6.38B	$27.52B
Real Options Value	$12.00B	$23.16B	$58.84B
Total Cost	$10.00B	$24.00B	$9.09B
Strategic Real Options-based Relative Return Ratio	1.00	1.9	4.9

- ***Collaboration is critical.*** OA as an acquisition, development and deployment framework will not succeed without the support of a collaborative infrastructure to facilitate the introduction of multiple large, medium and smaller players and their necessary interactions with users of the systems (e.g., warfighters), the acquisition community, and Navy leadership. Significant investments will be required for the infrastructure necessary to enable all parties (acquirers, users, developers) to collaborate easily and effectively in an OA model.

- ***Performance monitoring is required.*** If the performance of acquisition strategies is not monitored over time, the probability of success will be greatly reduced. Performance measurement systems (i.e. performance accounting software), in conjunction with predictive forecasting software programs, provide additional analytic support to IWS systems-acquisition strategies.

These research results, along with components of the KVA+RO framework and key findings from the analysis, are summarized in this report.[3]

B. Summary

IWS systems developed in a closed, proprietary model have performed well and provide substantial returns. However, a new paradigm is required to maintain military superiority and wage information-age warfare. Through open architected system development and open-business models, benefits such as reusable code, lower maintenance-upgrade costs, and greater vendor flexibility in supporting system module upgrades could be derived. Moreover, the Navy can leverage new technology by quickly adopting it to warfighter needs.

This study found that the "leave and layer" option for IWS replacement provided the lowest costs, highest ROIs, and highest strategic options value with the lowest risk. The results recommend use of the OA – leave and layer IWS replacement approach to support reengineered warfighting processes.

[3] The accuracy of our analysis is dependent on data and information provided by subject-matter experts. KVA analysis includes tests of the reliability of their estimates.

II. Introduction

Naval Open Architecture (Naval OA) is a multi-faceted, enterprise-wide business model and product-line strategy designed to fully capitalize on “open” computer design principles and architectures. Expanding on the technological open architecture (OA) model, Naval OA leverages, “open business models for the acquisition and spiral development of new systems that enable multiple developers to collectively and competitively participate in cost-effective and innovative capability delivery to the Naval Enterprise” (Mullen, 2006, August 28). The new OA business model requires a greater degree of collaboration among customers (e.g., warfighter), builders (e.g., small, medium, and large technology companies), and buyers (e.g., the acquisition community) than the existing closed, proprietary IWS business model. In the migration to an OA business model, billions of dollars in hardware and software development expenditures, along with subsequent maintenance costs, are at stake.

To understand the potential impact of OA technology and business models on naval warfighting processes and procedures, analytical tools are critical for decision-makers as they manage their portfolio of options. Portfolio management requires that these tools quantify the risks, costs, and net value of potential IWS acquisitions. The tools must be able to help identify where gaps exist in current processes and to project anticipated returns on investments to fill those gaps.

This study describes research conducted at the Naval Postgraduate School (NPS) using the Knowledge Value Added/Real Options (KVA+RO) valuation/risk portfolio management framework. KVA+RO is a comprehensive measurement tool set that defines, measures and evaluates total value of given IWS acquisitions. It captures data across a spectrum of organizations to compare outputs, processes, capabilities, risks, costs, and value (i.e. comparable revenue). KVA+RO analytically quantifies uncertainty and risk elements inherent in predicting the future, includes ways to mitigate these risks through strategic options and by analytically developing and allocating budgets to optimize project portfolios. Understanding uncertainties and mitigating the potential impact of risks significantly improves the likelihood of successful acquisition decisions.

In this study, KVA+RO is used to assess the implications of OA on SA procedures onboard the AEGIS and SSDS platforms. Focusing on systems interoperability, KVA methodology is first applied to generate knowledge-based, ROI metrics on individual sub-processes and watch stations involved in track-management processes. The potential impact of OA on track management processes and sub-processes is analyzed under several scenarios: ***"To Be," "Radical 1," and "Radical 2"*** for AEGIS and SSDS. Potential investments are then evaluated for AEGIS through real options analysis, resulting in net present value (NPV) of three strategic alternatives ranging from $6.4 billion to $27.5 billion over a nine-year period and options valuations of from $23.2 to $58.8 billion.

III. Lessons from the "Open" Solutions Movement

Disruptive forces and accelerating shifts in technology have enabled organizations to leverage open technology platforms to achieve greater productivity and efficiency levels. These "open" solutions offer new possibilities for solving business problems, provide business interoperability by standardization and technology transparency, and decrease time to market for key products and services. Organizations are adopting open technology platforms and open-source software for critical business needs, moving into mainstream business practices in corporations such as IBM, Google, Intel, JPMorgan Chase, Merrill Lynch and Pfizer.

One manifestation of the movement toward "openness," yet to be embraced by the Department of Defense (DoD), is the open-source software movement. Germany, Australia, the United Kingdom, Finland, Norway, Canada, China, Japan and Brazil are among the increasing number of governments embracing open-source software. Open-source software is growing at such a rate that it represents the most significant all-encompassing and long-term trend that the software industry has seen since the early 1980s, according to a recent study by International Data Corporation (IDC). IDC's survey of over 5,000 developers in 116 countries found that open source software is being used by 71% of developers in the world and is in production at 54% of their organizations.

Open-source software development site SourceForge.net reported more than 129,000 projects in 2006, up from 1,362 projects in 2000. Google's 2006 "Summer of Code" open-source initiative has 630 collaborative projects pumping more than $3 million back into the open-source community. There are now more than 55 Open-Source Initiative (OSI) certified open-source licenses available given the popularity of open-source software.[4] The success of this movement has been predicated on

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[4] According to OSI, the most commonly used licenses are: Apache License, GNU General Public License (GPL), GNU Lesser General Public License (LGPL), Modified BSD (Berkeley Software Distribution) License (new BSD) and Mozilla Public License (MPL). MPL is the most widely used since 1998. A NASA license is also available (OSI, 2006).

the ability of the multiple parties involved to easily collaborate across organizational, field-specific, and national boundaries. While this approach to software development may not directly apply to security-sensitive systems such as IWS, lessons can be learned by examining the results of this movement in the commercial world.

A. Collaboration is Key

As with the use of the OA technology and business model, open-source is built on the tenants of open access and collaboration. The lessons learned when "openness" is applied to system development and business models from the open-source movement is that such approaches allow access to a wider development community that can adapt, improve and fix software at a faster and more agile pace than can a proprietary vendor. Organizations are also not locked-into one vendor or product.

Google, for example, has acknowledged that the open architecture of Google Maps, allowing external developers to build applications on top of it, greatly contributed to the mapping service's functionality and diversity at a greater level than the company could have done internally (Perez, 2006, March 6). In 2005, IBM opened access to 500 corporate software patents, forfeiting $10 million dollars in annual royalties. According to IBM, technological advances are often dependent on shared knowledge, standards and collaborative innovation (IBM, 2005, January 11). IBM believes that by being allowed access to those patents, open-source developers will help foster continued innovation.

It's critical to note that the full potential of OA and open-business model approaches cannot be achieved without a basic collaborative technology infrastructure. The ease with which all parties share ideas, compare requirements, develop solutions, test system capabilities, and finally participate jointly in deploying systems is dependent on their commitment to collaborate openly and fully with each other. This can only be facilitated, realistically and practically, through collaborative technology. Benefits from this type of approach have been previously demonstrated in shipyard planning where the use of product lifecycle management (PLM) collaborative software added tremendous potential value to the process (Komoroski, C., Housel, T., Hom, S., & Mun, J., 2006, October).

B. Open Architecture and the Department of Defense

Computer software plays a critical component in maintaining the nation's defenses. For example, less than 10% of its functionality was provided by software when the F-4 fighter was developed in the 1960's; at least 80% of the F/A-22's functionality is software related (GAO, 2004, March). Although the DoD spends billions of dollars to develop and maintain rights to millions of lines of code, such software cannot be accessed or modified by anyone but the original vendor because of its proprietary nature (Payton, 2006, August 14). Moreover, the DoD will spend as much as $12 billion on reworking software for major weapons acquisitions programs—30% of its estimated budget of $40 billion for research, development, testing and evaluation in Fiscal Year 2006 (Wait, 2006, July 3). Consequences resulting from the lack of OA and open business models include:

- increased development and maintenance costs for information technology;
- lock-in to obsolete proprietary technologies;
- inability to extend existing capabilities in months versus years; and
- lack of interoperability due to opacity and stove-piping of information systems. (Herz, J.C., Lucas, M., & Scott, J., 2006)

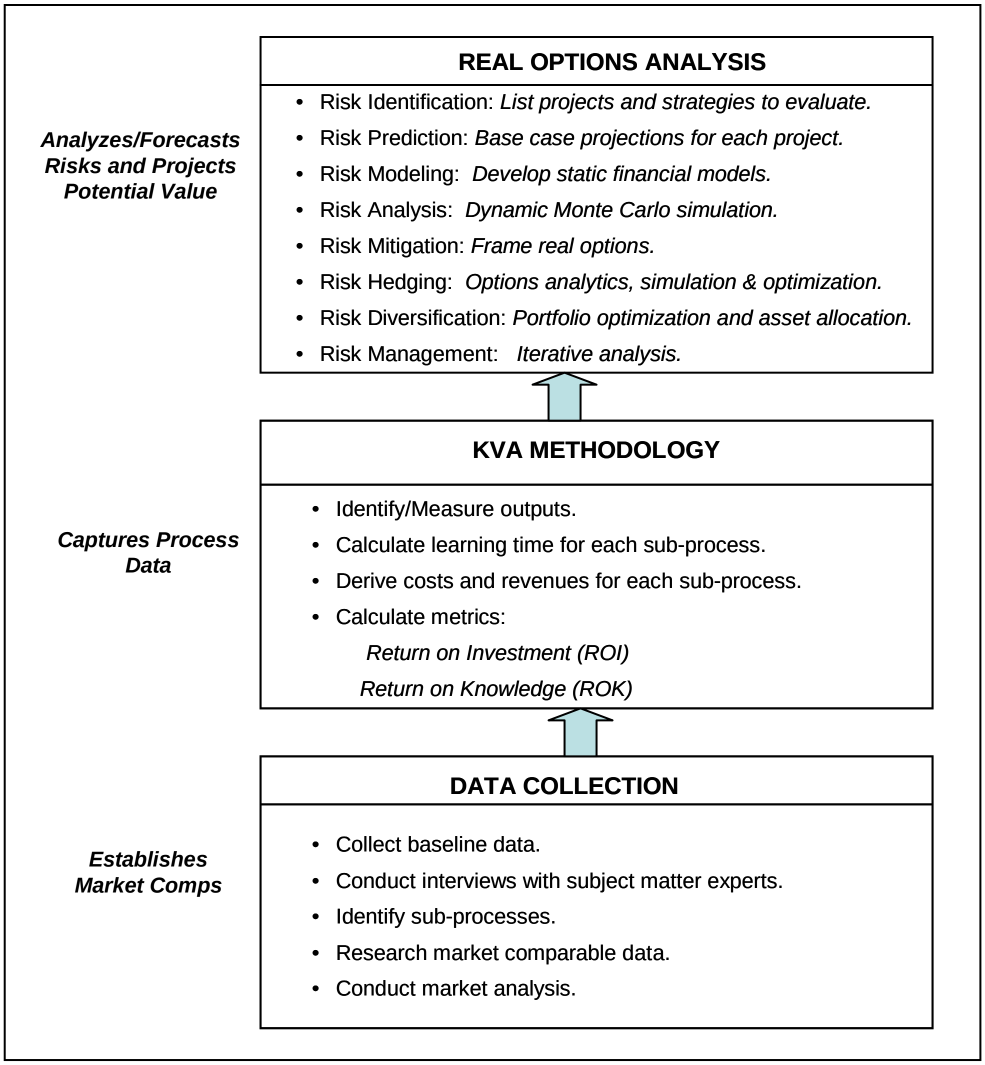
The DoD has at least 115 open-source software applications used in more than 250 applications. However, IWS software acquisitions are still made with the same industrial-age business models used to acquire ships, tanks and other physical machinery (Payton, 2006, August 14). The traditional business model of purchasing physical goods and services falls short when applied to acquiring digital assets like IWS technology. New business models are required to acquire IWS technology to wage information-age warfare requiring responsiveness and agility, according the Deputy Under Secretary of Defense for Advanced Systems and Concepts, Dr. Sue Payton (Payton, 2006, August 14). Moving to an open architecture model maximizes IT acquisitions by saving development dollars, reducing development cycles, and fostering new and innovative solutions and capabilities.

Modern, analytical tools are also necessary to deploy an open solutions business strategy. These tools must measure the operational value of a system from the warfighter's perspective, identify areas of deficiencies in capabilities, and flag areas for process improvement. Traditional measurement tools used for cost analysis cannot calculate the *total value* of a system, particularly operational value provided by specific process improvements. At the tactical level, an operator does not define capabilities merely in cost terms but also in time, efficiency and effectiveness gains like processing more targets within a given time period. Given new potential threats, such as "swarm" attacks where there may be thousands of targets at any one time, the warfighter's perspective in developing open and agile systems is critical. Focusing on the potential cost reductions from the OA and open business models approach may lead developers and acquirers away from the real needs of the warfighter. Maintaining a focus on the potential value produced, in addition to potential cost savings, is critical to the success of OA and open business models.

IV. KVA+RO Framework

The KVA+RO methodology provides an equal focus on the potential value and cost of new IWS systems. KVA+RO measures operating performance, cost-effectiveness, return on investments, risk, real options (capturing strategic flexibility), and analytical portfolio optimization. In this study, it was applied to the problem of finding the most promising solution for replacing aging IWS systems such as AEGIS and SSDS to support reengineered warfighting capabilities. KVA+RO analysis empowers decision-makers and supports IWS acquisition strategies by providing performance-based data and scenario analysis. Analyses like ROI on individual IWS projects and programs, as well as processes and sub-processes (e.g., track management processes in the present study) supported by IWS systems can be examined within a portfolio of acquisitions framed through the KVA+RO methodology. An overview of the framework is shown in Figure 1.

Figure 1. NPS Valuation Framework



The framework has been used in a variety of NPS analyses, including evaluating the potential impact of commercial-off-the-shelf (COTS) technology on naval maintenance/modernization processes. In the study involving one specific area of shipyard planning for maintenance alterations, cost savings were projected to exceed $40 million per year and manpower requirements drastically reduced with commercial-off–the-shelf, three-dimensional scanning/visualization technology and collaborative PLM technology (Komoroski, C., Housel, T., Hom, S., & Mun, J., 2006, October). Key components of the NPS Valuation framework are further discussed in this section.

A. Knowledge-based Metrics: Knowledge Value Added (KVA)

KVA measures the value provided by human capital assets and IT assets (e.g., IWS systems + human operators) by an organization, process or function at the sub-process level. It monetizes the outputs of all assets, including intangible knowledge assets. Capturing the value embedded in an organization's core processes, employees and IT enables the actual cost and revenue of a product or service to be calculated. Figure 2 identifies the types of assets used to produce output; outputs can be products or services produced by that organization.

Figure 2. Measuring Output

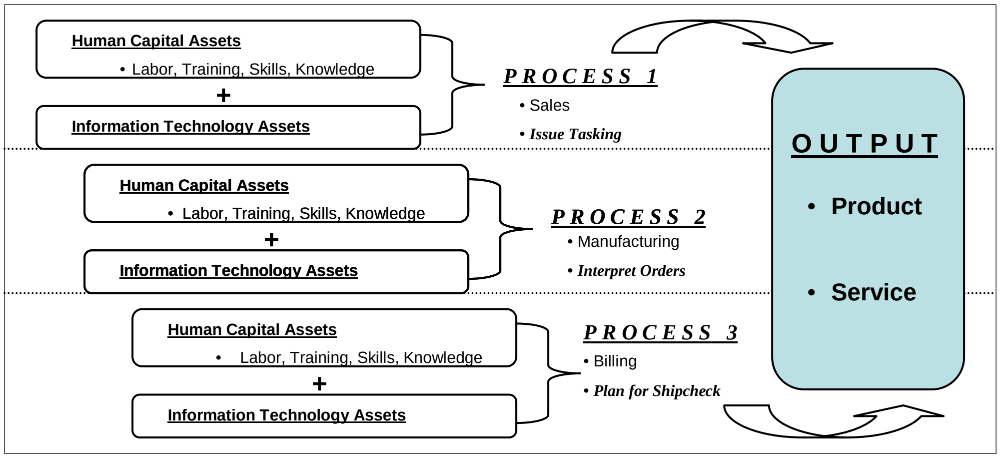


Figure 3 shows how KVA process costing differs from traditional accounting methods.

Figure 3. Comparison of Traditional Accounting versus Process-based Costing

Traditional Accounting		KVA Process Costing	
Compensation	$5,000	Review Task	$1,000
Benefits/OT	1,000	Determine Op	1,000
Supplies/Materials	2,000	Input Search Function	2,500
Rent/Leases	1,000	Search/Collection	1,000
Depreciation	1,500	Target Data Acq	1,000
Admin. And Other	900	Target Data Processing	2,000
Total	**$11,400**	Format Report	600
		Quality Control Report	700
		Transmit Report	1,600
		Total	**$11,400**

Explains what was spent (Traditional Accounting) — *Explains how it was spent* (KVA Process Costing)

As seen in Table 1, total value is captured in two key metrics: ROI and ROK. While ROI is the traditional financial ratio, ROK identifies how a specific process converts existing knowledge into process outputs so decision-makers can quantify costs and measure value derived from investments in productive assets. A higher

ROK signifies better utilization of knowledge assets. If IT investments, such as existing IWS systems, do not improve the ROK value of a given process, steps must be taken to improve that process's function and performance.

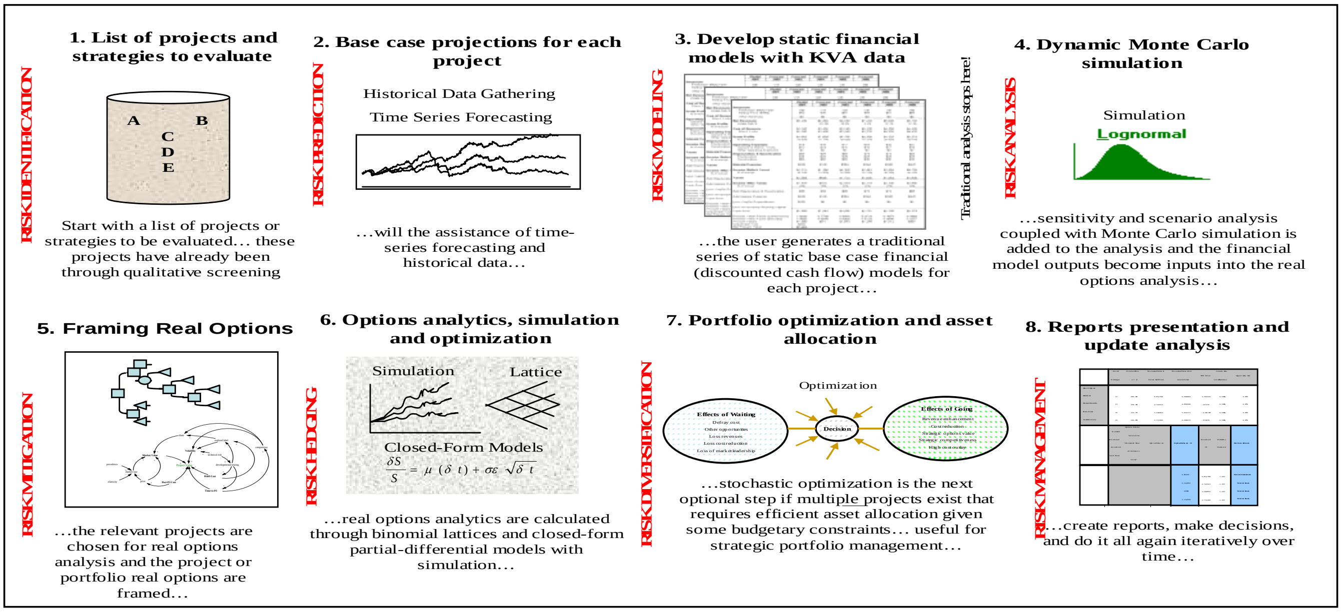
Table 1. KVA Metrics

Metric	Description	Type	Calculation
Return on Knowledge (ROK)	Basic productivity, cash-flow ratio	Sub-corporate, process-level performance ratio	Outputs-Benefits in Common Units Cost to Produce Output
Return on Investment (ROI)	Same as ROI at the sub-corporate, process level	Traditional investment finance ratio	(Revenue-Investment Cost) Investment cost

B. Risk Analysis: Real Options (RO)

Potential strategic investments can then be evaluated with real options analysis based on KVA data. This analysis is a robust and analytical process incorporating the risk identification (applying various sensitivity techniques), risk quantification (applying risk-based Monte Carlo simulation), risk valuation (applying real options analysis), risk mitigation (utilizing real options framing), and risk diversification (employing analytical portfolio optimization) using the *Real Options SLS* and *Risk Simulator* software programs. Figure 4 reflects the complex calculations for integrated risk analysis in KVA+RO.

Figure 4. Integrated Risk Analysis



C. Beyond Concept: KVA+RO Implementations

Moving beyond a concept stage, the KVA+RO framework is being implemented in SPAWAR and in the Army Rapid Equipping Force project. KVA+RO is being used in both projects to improve processes, reduce cycle-times and costs, and increase value by allowing Navy executives to acquire intelligence systems via a portfolio approach and by getting the Army troops in the field (i.e., Iraq and Afghanistan) what they need very quickly through new rapid acquisition processes.

V. Proof-of-Concept Case Study: Situational Awareness Onboard AEGIS and SSDS Platforms[5]

This proof of concept case study is designed to assist PEO IWS, Open Architecture Division, with its mandate of implementing OA in the Navy. The case is prepared from a warfighter perspective because the value of OA must be proven to the ultimate end-user. This perspective also permits a review of how OA can lead to flexible system acquisition and development to enable reengineered processes that will provide better performance in core warfighting processes such as SA.

In a multi-phased approach, KVA+RO was applied to SA-track management procedures used in the AEGIS and SSDS platforms. As illustrated in Figure 5, the total functionalities of AEGIS and SSDS systems are very broad so we focused our research on SA because it appeared to be the most promising area for upgrading and reengineering according to subject matter experts. The goals of this research were to:

- Demonstrate the efficacy of the KVA-RO framework to evaluate reengineering designs for warfighting core processes (i.e., SA-track management) in terms of the ROI and strategic option value of various OA approaches to replacing aging IWS systems.
- Determine which elements of the track management process could be reengineered using an OA approach
- Identify areas of improvement for current surface ship track-management processes using the existing two IWS systems: AEGIS and SSDS.

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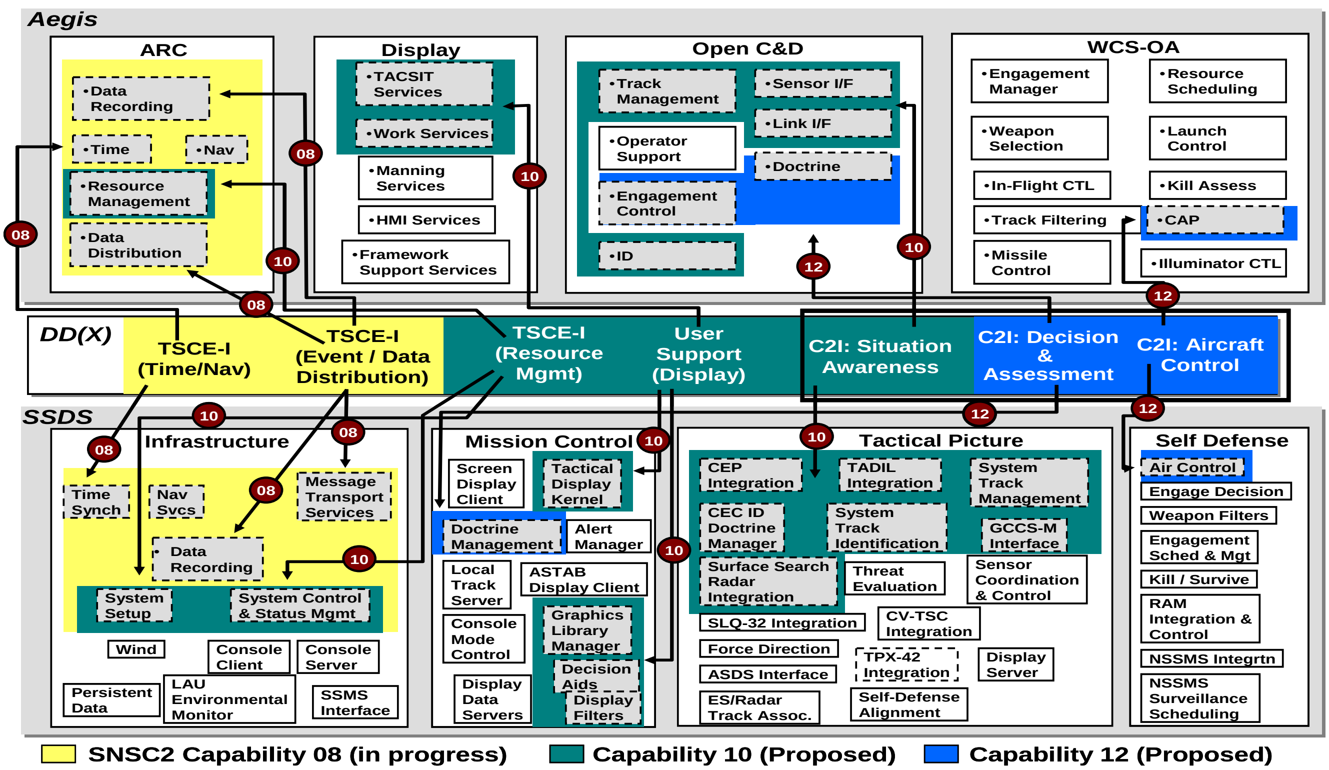
5 Information collected from subject-matter experts (SMEs) from Surface Warfare Fleet and training commands at Dahlgren (AEGIS) and Wallops Island (SSDS). Information gathered from SMEs then aggregated to provide an average for each process to ensure accuracy. Additional information collected, including process flow diagrams, use-case diagrams and literature review, to develop baseline data.

Figure 5. Planned Reuse of Aegis and SSDS in DD(X)



Source: MacRitchie, J., "Open Architecture & SNSC2," Presentation June 29, 2005, p. 12.

A. Background

In the late 1990s, the DoD articulated a vision for network-centric (or "net-centric") warfare in which networking military forces would facilitate information sharing and collaboration, leading to enhanced SA. Information superiority is vital to enhanced SA, rapid decision-making, improved efficiency, speedy execution and mission effectiveness. A high degree of interoperability is required to achieve information superiority.[6] Lack of interoperability between the services makes it difficult for the warfighter to distinguish "friend" from "foe" and to make critical decisions—potentially delaying military response times or contributing to lethal mistakes. Figure 6 shows a scenario in which a sea-based system and a land-

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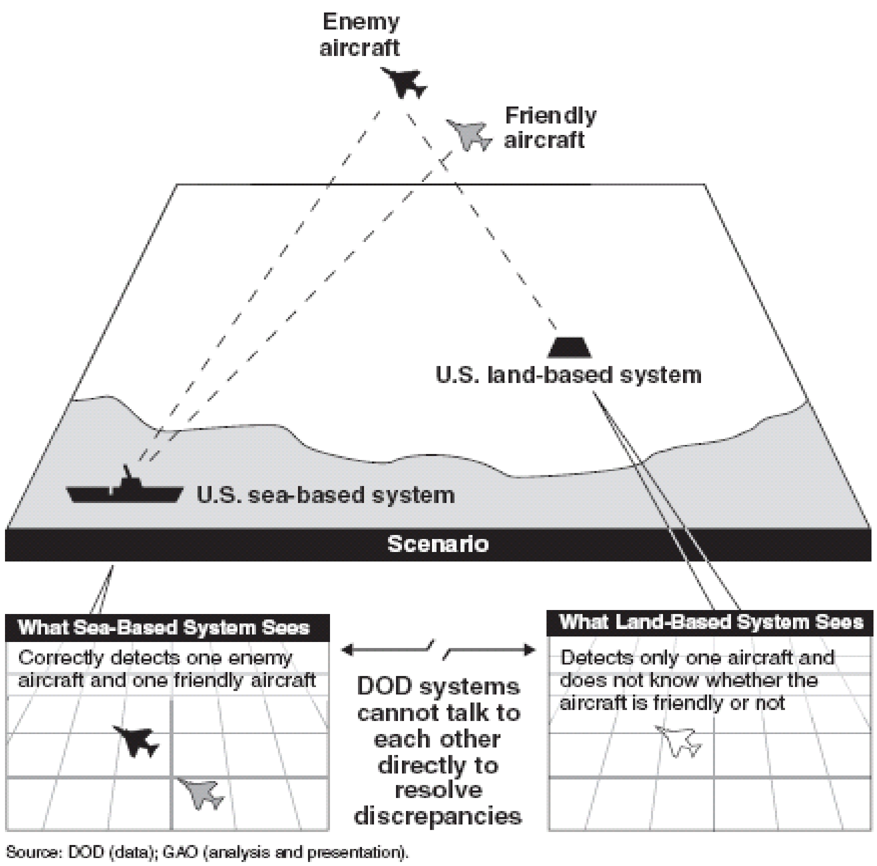
[6] The DoD defines interoperability as the ability of systems, units, or forces to exchange data, information, materiel, and services to enable them to operate effectively together.

based system are tracking aircraft and are unable to integrate their views of a battlefield.

Figure 6. Scenario for Tracking Threats without Benefit of Interoperable Systems



Source: Government Accountability Office. (2006, January). *DOD management approach and processes not well-suited to support development of global information grid.* Washington, DC. GAO Report GAO-06-211, p.6.

To achieve information superiority and enable net-centric warfare, the DoD has been developing the Global Information Grid (GIG). Interoperable systems are critical to the GIG for joint military operations and to allow users access to data on demand, to share information in real-time and to collaborate in decision-making from almost any location. Development of this capability is ultimately dependent on support from reengineered SA systems within IWS suites.

B. Naval Challenges

The Navy must develop architectures that meet the integration requirements for the GIG. This is a critical requirement in designing and implementing new IWS systems built within the OA framework. In addition, the Navy must resolve the following issues that are a result of legacy technology systems, such as the aging IWS systems.

- ***Limited computational and operational capability.*** Systems operating at 99% capacity in non-stressed environments.
- ***Difficulty or inability to add new warfighting missions.*** "Stove-piped" systems diminish interoperability and ability to meet national security threats.
- ***Prohibitive software maintenance costs.*** Some $3+ billion spent across Future Years Defense Plan in PEO IWS to develop and maintain computer programs. Additional testing and certification required when new capabilities added.

The Navy has historically acquired IWS systems that are proprietary in design and engineering, require unique parts, equipment, and services to support them, are supported by a limited number of suppliers, and become very expensive to maintain (Strei, 2003, April 1). Moreover, systems and/or platforms were entirely eliminated rather than upgraded or modernized because of prohibitive costs. Rapid technological obsolescence, compounded by exorbitantly escalating costs for proprietary systems are daunting challenges because design, development, and acquisition timelines can span as much as 15 years before a military platform reaches operating forces (Strei, 2003, April 1).

C. Naval Open Architecture and Open Business Models

OA and open-business models propel the Navy into the next era of joint interoperability while resolving legacy issues that provide new benefits, including:

- ***Lower lifecycle costs for IWS systems***. Total cost of ownership decreases due to increased maintainability, interoperability, upgradeability and use of a wider variety of vendors.

- ***Better performing systems.*** Ability to rapidly upgrade hardware and software with the latest technology enables greater capabilities, efficiencies and interoperability to enable reengineered warfighting processes.

- ***Improved interoperability for joint warfighting.*** Software reuse and modularity facilitates interoperability between systems that use an open architecture framework.

- ***Facilitating competition and increasing cooperation between commercial and military electronics industries.*** Moving away from proprietary systems enables a broader range of ideas and technological solutions.

Guiding principles behind Naval OA are modularity, reusability, interoperability, lifecycle affordability and collaboration and competition. In adopting an open, OA strategy based on commercially available, non-proprietary information technology (IT) standards, interfaces and formats, the Navy will need to increase collaboration (e.g., supported by readily available collaborative product lifecycle management technology) to spur competition and fuel innovation in the acquisition lifecycle.

Ease of collaboration is critical to Naval OA to ensure that multiple vendors compete, including the smaller, more nimble companies. Collaboration also provides the infrastructure necessary to facilitate all parties sharing critical requirements and performance information to reduce system modification, re-fresh or replacement cycle-times. As such, collaborative capabilities will facilitate moving OA beyond a purely technical focus to a more encompassing open-business model, one advocated by CNO Admiral Mullen. As noted earlier, Admiral Mullen's vision for open architecture isn't limited to systems built to a set of open standards, but focuses on open-business models tapping into a multiple-developer network to deliver innovative, cost-effective and rapid, spiral acquisition capabilities to the Navy.

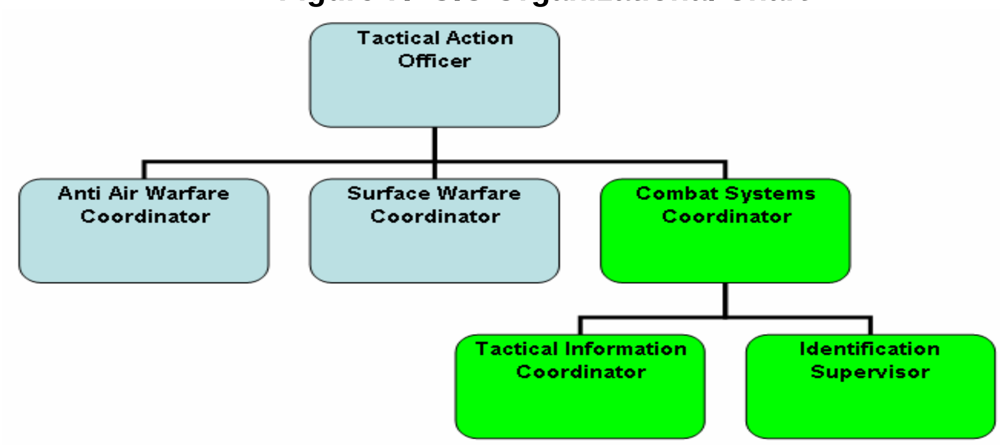
Migrating to an OA environment has been slow, however, despite the Navy's early adoption of open source strategies. Encouraged by the cost-effective advantages gained through the Acoustic Rapid commercial off –the-shelf

Insertion/Advanced Processor Build (ARCI/APB) program, Admiral Mullen noted in a recent memo his disappointment with the slow pace of adoption and advocated rapid transition to the open-business model (Fein, 2006, September 11).

D. SA: Track-management Processes

Track management, a fundamental capability inherent to all IWS SA capabilities for surface ships, is the process by which friendly and enemy forces are detected, identified, monitored, updated and communicated throughout the area of operations (AOR). The track management process within a Combat Information Center (CIC) is very complex, sophisticated and involves multiple watch stations and technological systems. AEGIS and SSDS have different SA procedures and policies, and track-management functions within the CIC. Although variations exist in track-management processes, watch stations are fairly consistent on both AEGIS and SSDS ships. Figure 7 is a generalized organizational chart of CIC personnel directly involved in track-management processes.[7]

Figure 7. CIC Organizational Chart



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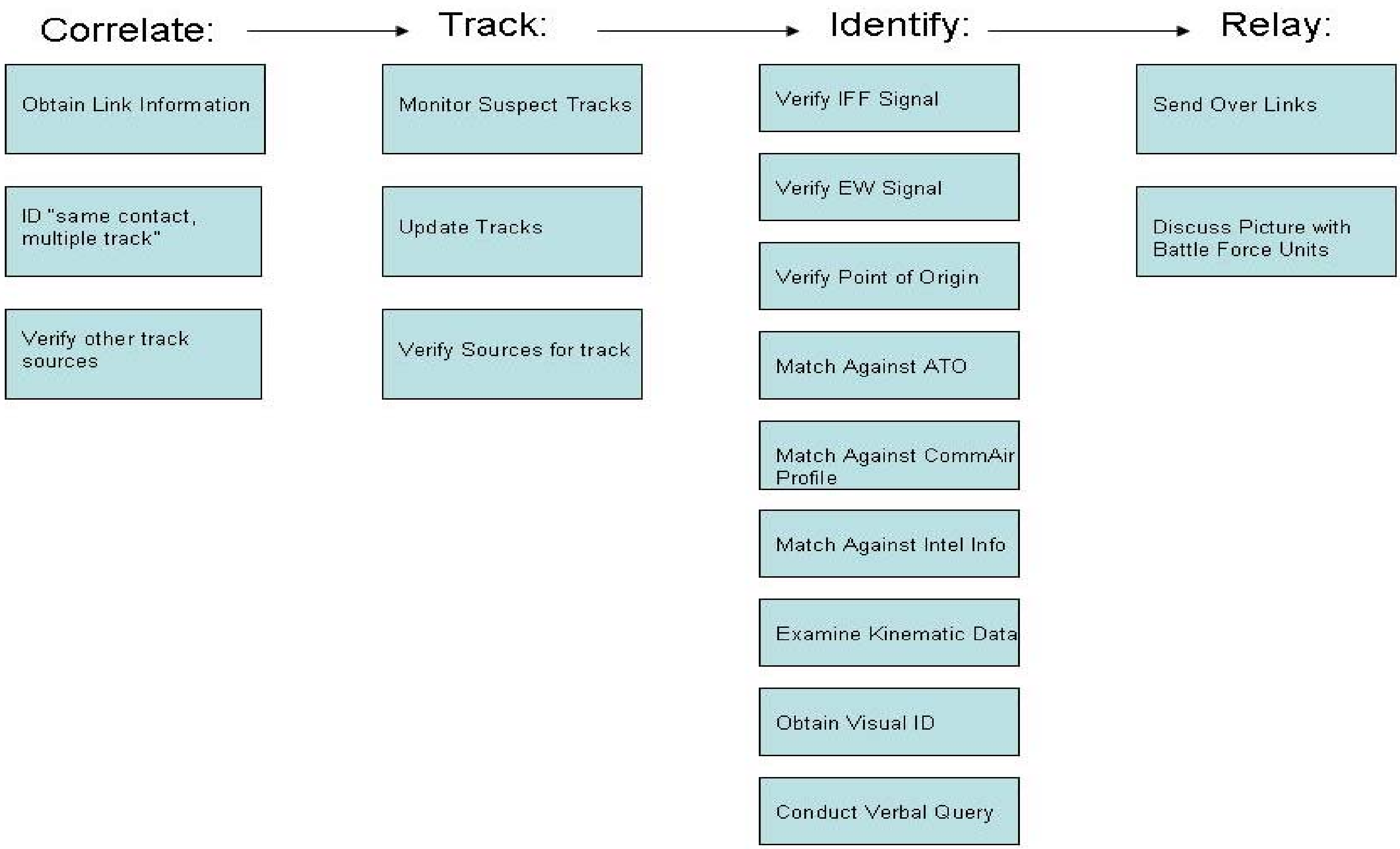
[7] Although watch stations talk to specific tasks and responsibilities, in an actual CIC, all personnel listed can be actively involved in any, or all, aspects of track management (correlation, identification, tracking, and relaying).

Track-management processes entail various sub-processes, as seen in Figure 8.[8] This graphic is an aggregated view for both AEGIS and SSDS platforms consisting of four principal processes and 17 sub-processes.

Figure 8. Track Management Sub-processes



8 Figure derived from numerous SMEs from AEGIS and SSDS communities. While sub-processes may differ from ship to ship, SMEs concluded that the four primary processes reflect track management procedures conducted within a CIC. SMEs agreed that the 17 sub-processes shown reflected individual tasks appropriate for this limited research. SMEs also concluded that there is no definitive sequential order in which specific tasks occur; however, the figure provides a potential sequence.

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VI. Case Study Results: Potential Impact of OA

The potential impact of OA on AEGIS and SSDS platforms was calculated through KVA+RO in a multi-phased approach. In addition, KVA data estimates and real options models were based on the assumption that functional upgrades would primarily be in the SA area with the remaining modules providing at least the same capabilities as the current AEGIS IWS system.

KVA methodology was first applied to derive potential benefits in SA processes within AEGIS and SSDS-class ships (i.e., 84 Destroyers and Cruisers). Track-management sub-processes by process category (and by watch station in Appendix B) were evaluated under four improvement scenarios (*"As Is," "To Be," "Radical 1," and "Radical 2"*). The following assumptions were used to calculate the data:

- Integration with middleware until Category 3 Open Architecture Computing Environment (OACE) level has been reached for systems being evaluated
- Use of OA approach to developing the IWS systems and use of Commercial-off-the-shelf (COTS) equipment

Steps in calculating KVA data were:

1. Identify core processes and sub-processes.
2. Establish common units and level of complexity to measure learning time.
3. Calculate learning time (i.e., knowledge surrogate) to execute each sub-process.
4. Designate sampling time period long enough to capture representative sample of the core processes' final product or services output.
5. Multiply learning time for each sub-process by number of times sub-process executes during sample period.

6. Calculate cost to execute knowledge (learning time and process instructions) to determine process costs.

7. Calculate ROK (ROK= Revenue/Cost) and ROI (ROK= Revenue-Cost/Cost).

During Phase 2, real options analysis focused on the options for improving (*Leave and Layer* option) or replacing (*Retrofitting* option) the AEGIS IWS system. The option to continue with the current proprietary systems approach was provided as a baseline for comparison purposes. Future research would allow us to examine all AEGIS modules for potential upgrading and would likely result in even higher ROI estimates as well as real options valuations.

A. KVA Results: ROK and ROI

ROK and ROI values provide insights into sub-processes that could be reengineered to achieve maximum operational efficiency. Aggregated results for AEGIS and SSDS are shown Figures 9 and 10. The "As Is" provides a baseline ROI/ROK performance measure for comparison of the three process reengineering designs. The three redesigns essentially represent the effects of increasing levels of automation in the track management process.

Figure 9. KVA Results: ROK and ROI Estimates

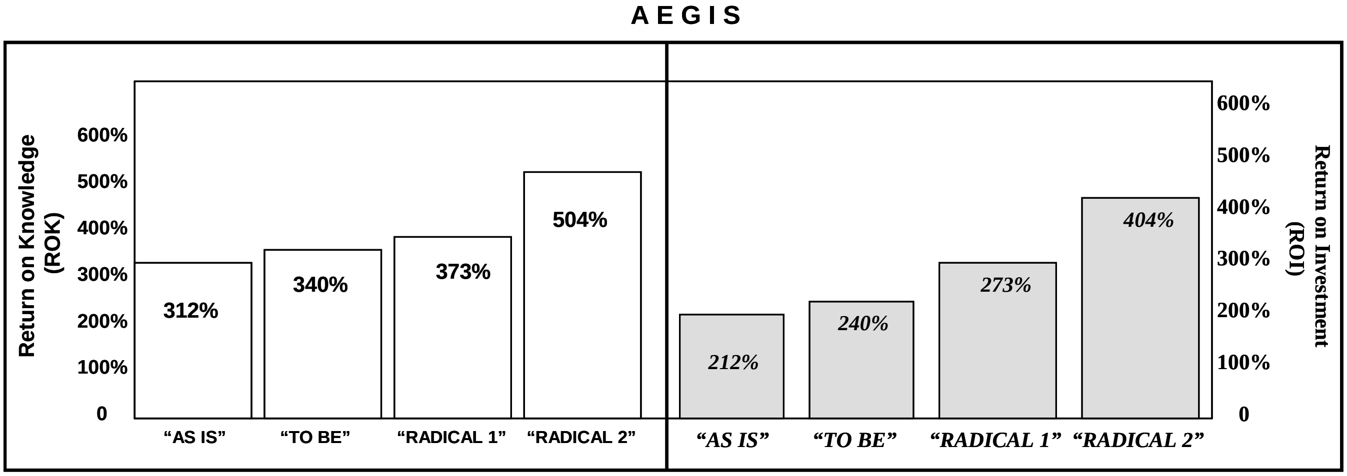
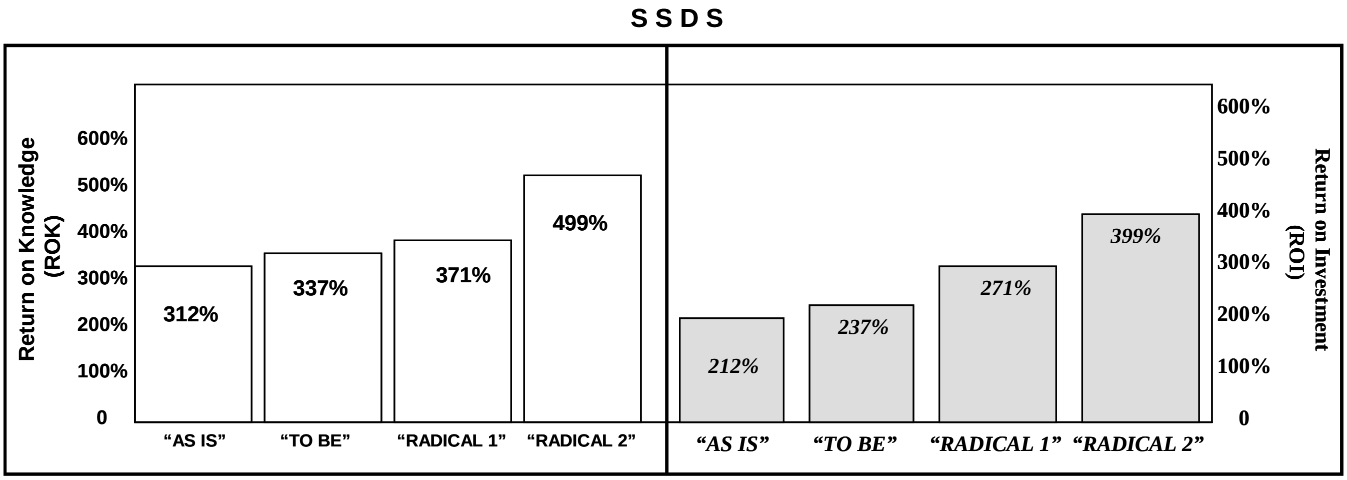


Figure 10. KVA Results: ROK and ROI Estimates



OA has the potential to provide these operational performance improvement benefits: decreased training time for operators of systems, decreased "touch time" on processes by replacing manual processes with new automated capabilities, and increased efficiency through seamless integration of multiple system components. As shown in Table 2 below, the cumulative impact of OA on the track-management processes results in significant improvement in three of four areas.

Table 2. Process Reengineering Impacts: Process Level and Cumulative

	"To Be"	"Radical 1"	"Radical 2"	Cumulative Impact
CORRELATE		X	x	x
TRACK	X	X	x	x
IDENTIFY	X	x	X	x
RELAY				

Tables 3 through 6 are ROK and ROI results by core processes and sub-processes for AEGIS and SSDS. The ROI estimates demonstrate that as various system functionalities of the existing track-management process are upgraded, a corresponding performance improvement is derived in those areas. This more detailed analysis suggests where OA based system upgrades should be applied to achieve the best results. For example, the core process of correlate and identify have the greatest potential to benefit from an OA approach to system development. These estimates also provide the basis for the real options analysis projections staged over a 9-year period.

Table 3. Detailed ROK Estimates for AEGIS

	AS IS	TO BE	RAD 1	RAD 2
CORRELATE				
Obtain Link Information	3521%	3407%	3163%	2733%
Identify "Same Contact, Multiple Track"	9%	9%	2161%	1856%
Verify Other Track Sources	5%	5%	5%	4%
Correlate sub-total	***1284%***	***1241%***	***1606%***	***1396%***
TRACK				
Monitor Suspect Tracks	2%	1%	1%	1%
Update Tracks	3%	3%	461%	410%
Update GCCS-M	3%	191%	184%	169%
Track sub-total	***2%***	***6%***	***42%***	***36%***
IDENTIFY				
Verify IFF signal	902%	869%	806%	707%
Verify EW emissions	9%	9%	8%	609%
Verify Point of Origin	2%	4221%	3921%	3432%
Match Against ATO	2%	4306%	3990%	3482%
Match Against CommAir Profile	963%	935%	863%	743%
Match Against Intel Information	3%	3%	3%	3914%
Examine Kinematic Data	4%	4%	3%	3%
Obtain Visual ID	0%	0%	0%	0%
Conduct Verbal Query	1%	1%	1%	1%
Identify sub-total	***108%***	***160%***	***150%***	***426%***
RELAY				
Send Over Links	13%	12%	11%	10%
Discuss Picture with Battle Force Units	2%	1%	1%	1%
Relay sub-total	***3%***	***2%***	***2%***	***1%***
TOTALS	**312%**	**340%**	**373%**	**504%**

Table 4. Detailed ROK Estimates for SSDS

	AS IS	TO BE	RAD 1	RAD 2
CORRELATE				
Obtain Link Information	3493%	3380%	3126%	2698%
Identify "Same Contact, Multiple Track"	9%	9%	2630%	2258%
Verify Other Track Sources	5%	5%	4%	4%
Correlate sub-total	***1274%***	***1231%***	***1612%***	***1401%***
TRACK				
Monitor Suspect Tracks	2%	1%	1%	1%
Update Tracks	4%	3%	646%	575%
Update GCCS-M	2%	114%	110%	101%
Track sub-total	***2%***	***4%***	***47%***	***40%***
IDENTIFY				
Verify IFF signal	890%	857%	792%	695%
Verify EW emissions	10%	9%	9%	574%
Verify Point of Origin	2%	3789%	3505%	3067%
Match Against ATO	2%	3913%	3610%	3149%
Match Against CommAir Profile	1026%	996%	916%	788%
Match Against Intel Information	3%	3%	3%	3788%
Examine Kinematic Data	4%	4%	4%	4%
Obtain Visual ID	0%	0%	0%	0%
Conduct Verbal Query	1%	1%	1%	1%
Identify sub-total	***112%***	***159%***	***148%***	***416%***
RELAY				
Send Over Links	18%	17%	16%	14%
Discuss Picture with Battle Force Units	1%	1%	1%	1%
Relay sub-total	***3%***	***2%***	***2%***	***2%***
Totals	**312%**	**337%**	**371%**	**499%**

Table 5. Detailed ROI Estimates for AEGIS

	AS IS	TO BE	RAD 1	RAD 2
CORRELATE				
Obtain Link Information	3421%	3307%	3063%	2633%
Identify "Same Contact, Multiple Track"	-91%	-91%	2061%	1756%
Verify Other Track Sources	-95%	-95%	-95%	-96%
Correlate sub-total	***1184%***	***1141%***	***1506%***	***1296%***
TRACK				
Monitor Suspect Tracks	-98%	-99%	-99%	-99%
Update Tracks	-97%	-97%	361%	310%
Update GCCS-M	-97%	91%	84%	69%
Track sub-total	***-98%***	***-94%***	***-58%***	***-64%***
IDENTIFY				
Verify IFF signal	802%	769%	706%	607%
Verify EW emissions	-91%	-91%	-92%	509%
Verify Point of Origin	-98%	4121%	3821%	3332%
Match Against ATO	-98%	4206%	3890%	3382%
Match Against CommAir Profile	863%	835%	763%	643%
Match Against Intel Information	-97%	-97%	-97%	3814%
Examine Kinematic Data	-96%	-96%	-97%	-97%
Obtain Visual ID	-100%	-100%	-100%	-100%
Conduct Verbal Query	-99%	-99%	-99%	-99%
Identify sub-total	***8%***	***60%***	***50%***	***326%***
RELAY				
Send Over Links	-87%	-88%	-89%	-90%
Discuss Picture with Battle Force Units	-98%	-99%	-99%	-99%
Relay sub-total	***-97%***	***-98%***	***-98%***	***-99%***
Totals	**212%**	**240%**	**273%**	**404%**

Table 6. Detailed ROI Estimates for SSDS

	AS IS	TO BE	RAD 1	RAD 2
CORRELATE				
Obtain Link Information	3393%	3280%	3026%	2598%
Identify "Same Contact, Multiple Track"	-91%	-91%	2530%	2158%
Verify Other Track Sources	-95%	-95%	-96%	-96%
Correlate sub-total	***1174%***	***1131%***	***1512%***	***1301%***
TRACK				
Monitor Suspect Tracks	-98%	-99%	-99%	-99%
Update Tracks	-96%	-97%	546%	475%
Update GCCS-M	-98%	14%	10%	1%
Track sub-total	***-98%***	***-96%***	***-53%***	***-60%***
IDENTIFY				
Verify IFF signal	790%	757%	692%	595%
Verify EW emissions	-90%	-91%	-91%	474%
Verify Point of Origin	-98%	3689%	3405%	2967%
Match Against ATO	-98%	3813%	3510%	3049%
Match Against CommAir Profile	926%	896%	816%	688%
Match Against Intel Information	-97%	-97%	-97%	3688%
Examine Kinematic Data	-96%	-96%	-96%	-96%
Obtain Visual ID	-100%	-100%	-100%	-100%
Conduct Verbal Query	-99%	-99%	-99%	-99%
Identify sub-total	***12%***	***59%***	***48%***	***316%***
RELAY				
Send Over Links	-82%	-83%	-84%	-86%
Discuss Picture with Battle Force Units	-99%	-99%	-99%	-99%
Relay sub-total	***-97%***	***-98%***	***-98%***	***-98%***
Totals	**212%**	**237%**	**271%**	**399%**

Table 7 summarizes how OA could specifically impact the sub-processes deriving most significant improvements: "Identify 'Same Contact, Multiple Track'," "Update GCCS-M," "Update Track," "Verify Point of Origin," "Match against ATO," "Verify EW Emissions" and "Match Against Intel Information." Each watch station at the CIC was affected (see Appendix B).

Table 7. Potential Impact of OA at Sub-process Levels

PROCESS	SUB-PROCESS	COMMENTS POTENTIAL IMPACT OF OA
CORRELATE	**"Identify 'Same Contact, Multiple Track'"**	• Reduces reliance on manual identification of multiple tracks and updating current tracks. • Automatically corrects anomaly of multiple tracks per target and update tracks. Only brief confirmation by the watch station operator necessary.
TRACK	**"Update GCCS-M"**	• Enhances operational value of systems through reduced time, manpower and training required to conduct process.
TRACK	**"Update Track"**	• Reduces reliance on manual identification of multiple tracks and updating current tracks. • Automatically corrects multiple tracks per target anomaly and update tracks, resulting in brief confirmation by watch station operator.
IDENTIFY	**"Verify Point of Origin"**	• Enables greater sensor and data integration, providing enhanced correlation in pinpointing origin of aircraft or ship. • Queries point of origin for friendly force contacts from an open GCCS-M system, and interrogates ATO neutral-force contacts from host nation airports (assuming data format standardized and provided by host nations.). • Facilitates interfaces to other systems to provide automated query for point of origin. • Frees watch standers to perform other tasks while providing faster data flow.
IDENTIFY	**"Match Against ATO"**	• Integrates info provided in ATO into the AEGIS and SSDS platforms, greatly reducing manpower requirements.
IDENTIFY	**"Verify EW Emissions"**	• Facilitates COTS-based environment for easier upgrades to accommodate greater processor speeds. • Enhances CIC efficiency through more timely SA. • Frees operators to perform other tasks.
IDENTIFY	**"Match Against Intel Information"**	• Streamlines sub-process with automatic updates requiring merely manual confirmation.

B. Value-risk Analysis: Strategic *Real Options* Analysis

Real options analysis was performed to determine the prospective value of alternative COAs for upgrading the AEGIS IWS in track management over a nine-year period with KVA data inputs. In all new options for IWS deployment, it was assumed that a collaborative technology infrastructure was present to facilitate the use of the OA system and open-business model approaches.[9]

Figure 11 illustrates the three main strategies laid out as a real options map. Strategy A is do nothing, leaving everything “As Is” with the ability to retire ships and their AEGIS systems within 10 years. Strategy B is the “DDX Open Architecture” (retrofit) option with new development within the first three years at a cost of $8 billion. Under this strategic path, follow-up is required—with retrofitting costing an additional $16 billion within 6 years after first-phased new development has been completed. Strategy C looks at the “Leave and Layer” option with a three-phased sequential compound option of “To Be,” “ Radical 1,”, and “Radical 2” implementation within 9 years.

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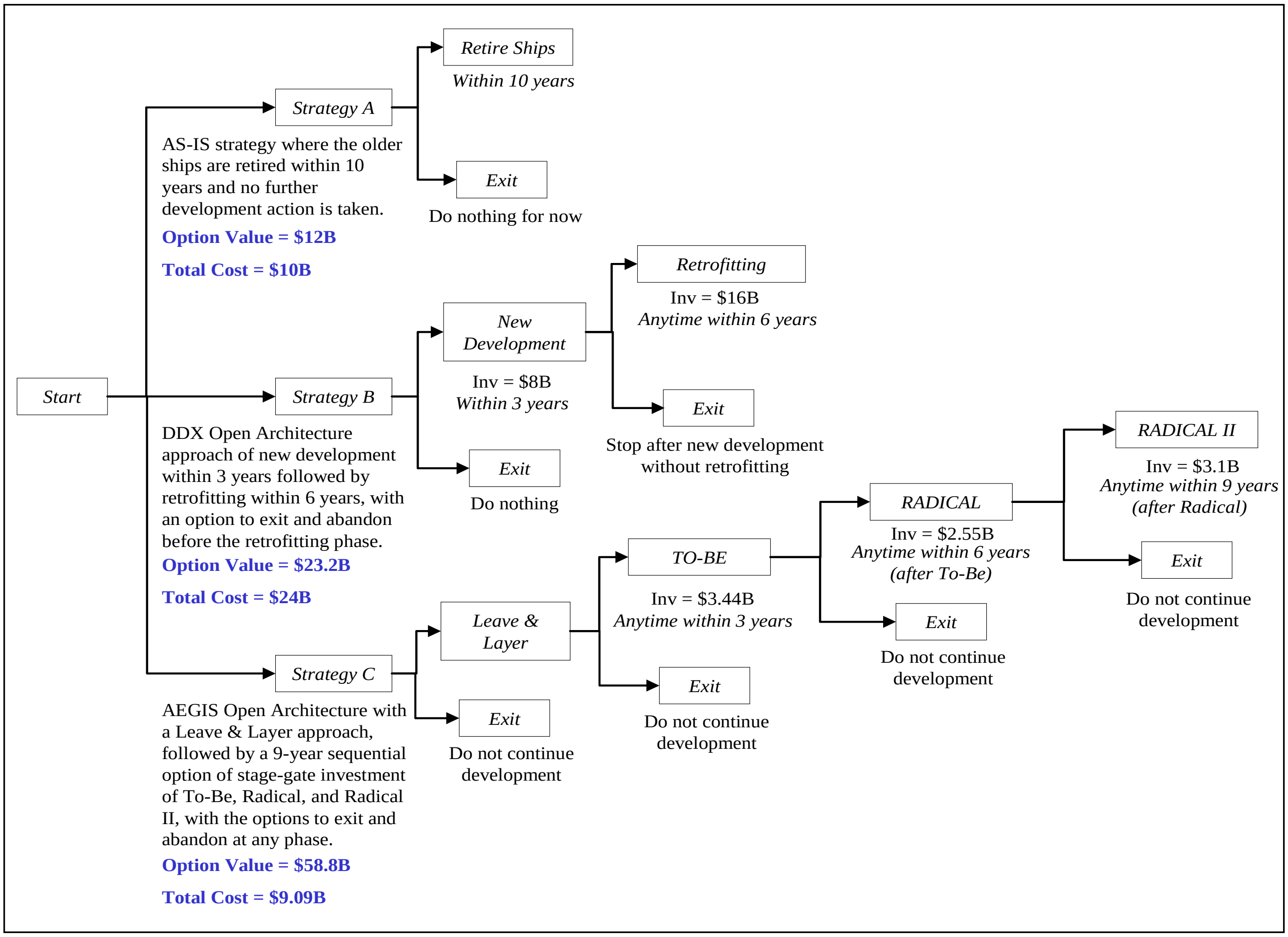
9 Estimates are based on historical data and additional information provided by SMEs. We have attempted to be as conservative as possible and have assumed very high potential volatility in both of the new IWS development options. Access to more precise performance data will help resolve uncertainties and risks over time.

Figure 11. Strategic Real Options Map



Strategy C is the option with the greatest potential value. As seen in Table 8 below, Strategy C provides 4.9 times the risk adjusted return of the “As Is” strategy versus Strategy B at 1.9 times the return. Strategy C’s incremental approach offers the lowest risk and numerous benefits, including less disruption to the rest of system and deriving benefits faster. It is the lowest total cost alternative with costs spread over a nine-year period, yet the program reaps incremental benefits from various functionality improvements throughout that time. This strategy provides the highest NPV.

Table 8. Real Options Valuation Results: Strategies A-C

	Strategy A	Strategy B	Strategy C
STRATEGIC OPTION	“As Is”	DDX OA “Develop and Retrofit”	AEGIS OA “Leave & Layer”
Net Present Value	$12B	$6.38B	$27.52B
Volatility	0%	80.5%	86.3%
Real Options Value	$12B	$23.155B	$58.84B
Strategic Real Options-based Return on Investment	N/A	72.36%	224.75%
Total Cost	$10B	$24B	$9.09B
Strategic Real Options-based Relative Return Ratio	1.0	1.9	4.9

Notes:

(1) The volatility measure quantifies uncertainty and risk levels in the strategy and calibrates them to account for the time required to complete the entire strategy.

(2) Strategic real options values are also computed, accounting for value of open architecture as laid out in the phased-gate development process.

(3) Strategic real options-based return on investment looks at real options valuation results and computes ROI based on the option values and implementation of costs each phase. The higher this ROI value, the more strategic and valuable or profitable a project.

“Leave and Layer” allows organizations to benefit from incremental adoption. Rather that executing a plan that requires everything to be accomplished at once, “leave and layer” enables existing systems to be reused successfully. NAVFAC successfully adopted the approach to provide a more efficient, lower cost contract management solution. NAVFAC architected a technology platform to allow it to build a layer of Web-based collaborative project management tools, while leveraging existing financial, HR, and scheduling systems. A number of applications were developed, including the collaborative eProjects application with a budget of $350,000 and completion in 10 months (Oracle, 2004). eProjects provides one-click schedule and cost status. Another application, eContracts, automates nearly 200 redundant screens per contract action.

In our analysis, Strategy B has the highest cost due to high up-front costs required to build the system within the first five years without deriving any benefits from the new system during that time. Both strategies B and C require the use of collaborative infrastructure to enable the open business model that would be most likely to produce these real options values. Strategy C, in fact, relies most heavily on collaboration to enable the kinds of benefits in rapid, spiral acquisition with greater competition and innovation from smaller players.

Summary

IWS systems that were developed in a closed, proprietary model have performed well and provide substantial returns. However, a new paradigm is required to maintain military superiority and wage information-age warfare. Through open-system development and open-business models, benefits such as reusable code, lower maintenance-upgrade costs, and greater vendor flexibility in supporting system modules could be derived. Moreover, the Navy can leverage new technology by quickly adopting it to military needs.

Significant investments are required for the infrastructure necessary to enable all parties (acquirers, users, developers) to collaborate easily and effectively in the new open-business model. Analytical tools are also required to track performance of the multiple parties involved in the development, acquisition and use of new system capabilities, in conjunction with the ability to adjust options models as uncertainties and risks are resolved over time. Performance measurement systems (i.e. KVA performance accounting software) and predictive, forecasting software programs plus risk certification training provide additional analytic support to achieve IWS systems acquisition strategies.

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Appendix A. Case Study Notes

1. Methodology

Case Study Approach:

The learning-time approach to KVA is used to conduct sub-process scenario analyses of “As Is,” “Radical 1,” and “Radical 2.” Core elements of KVA (such as “time-to-learn,” “number of personnel involved,” and “times fired”) produce a ratio of knowledge capital (ROK) resident in each process. ROK derives a common unit of measurement for each sub-process within the track-management process.

Data Collection:

Collecting data to conduct KVA analysis was difficult due to the complex nature of track-management procedures in the CIC. Outputs, learning time and touch time of the many sub-processes that comprise the entire procedure are not generally collected or retained. Also, training times and required OJT are targeted at specific watch stations rather than at specific processes within the Navy. Consequently, data was derived through numerous interviews with SMEs and review of Personal Qualification Standards (PQS). Multiple SMEs were contacted to collect an aggregated sample.

“To Be” Data:

Analysis based of situations that SMEs identified as optimal areas where open architecture could provide value to the operator. In addition, technical and legal issues of the “To Be” scenario were not assessed.

2. Discussion of Basic Assumptions Used in Calculations

Cost and Revenue Data

- Calculations based on a ship performing SA and track management processes 24 hours a day, 7 days a week operating an average of 35 weeks per year.

- Net present value in total revenue estimates is based on a 30-year system-life expectancy of ship.

- A contractor-margin approach was used to generate surrogate comparable revenue estimates. Contractor margin is defined as the amount market place would pay a group of contractors, with levels of knowledge comparable to the existing team, to perform the activities of the track management team (e.g the margin over current Navy costs for the track management team). This market-comps approach was used because there were no commercial processes directly comparable to track management activities in the military. Future studies would allow a wider range of potential commercially comparable processes to be assessed for comparability/fit revenue estimates.

- Surrogate comparable revenue estimates are conservative given that revenue calculations were based on six people in the SA, track-management process. In reality, more people may be involved in this process.

New Development/Retrofitting DD(x)

- PV Asset New Development: Calculated by translating hourly revenue of the combined SSDS/AEGIS "AS-IS" estimates to yearly revenue, calculating the present value of the yearly revenue based on a 30-year lifecycle, and assuming retrofitting on all current 84 Aegis destroyers/cruisers.

- PV Asses Retrofitting: Calculated by translating hourly revenue of the combined SSDS/AEGIS RADICAL estimates to yearly revenue, calculating the present value of the yearly revenue based on a 30-year lifecycle, and assuming retrofitting on all current 84 AEGIS destroyers/cruisers.

- Cost to Execute: Based on estimation from SMEs and refining based on historical costs of AEGIS.*

- Operations/Maintenance Costs: Based on historical costs of AEGIS and scaled down to account for open architecture.

- Timing: Based on estimates by SMEs.

Leave and Layer/AEGIS

- PV Asset: Calculated by translating hourly revenue of the combined SSDS/AEGIS estimates to yearly revenue, calculating the present value of the yearly revenue based on a 30-year lifecycle, and taking into account current placement on 84 destroyers/cruisers.

- Cost to Execute: Based on $5 billion development costs and scaled according to increases in knowledge units.

- Operations/Maintenance Costs: Based on historical costs of AEGIS and scaled down to account for open architecture.

- Timing: Based on estimates by SMEs.

3. Use of Data in Case Study Calculation

Item	Definition	Comments
No. of Personnel	Sailors and officers involved in performing sub-process.	—
Actions per Hour	Times each sub-process acted upon by watch-stander.	• Actions predicated on amount of contacts (air and surface) encountered during a typical hour within the CIC. Each contact must be acted upon. • Estimates based on a typical, six-month deployment. • Number of contacts based on average of open-ocean transit and operations in littorals.
Actual Work Time (AWT)	Specific amount of time required to accomplish action every time sub-process acted upon.	• Data captured in hourly units. • Although actions require only seconds, category captures data in hours to maintain continuity of units of time throughout analysis.
Total Work Time	Total amount of time each sub-process acted upon within an hour.	• *Formula= "AWT" x "Actions per Hour"* • Analysis in hourly units: when "Total Work Time" for each of sub-processes added together for each of the watch stations, total aggregate should remain below 1.0. If total exceeded 1.0, calculations are incorrect.
Actual Learning Time (ALT)	Total amount of time required to learn given sub-process.	• Learning time can be an aggregate of formal schools, distance learning, on-the-job training (OTJ) or any other training experience that falls under definition of "learning." • For this case, comprised of formal school training and OJT provided aboard ship. • Basic assumptions to ensure consistent estimates from SMEs: **a. Officer-SSDS** Individual completing initial officer training with no prior SSDS platform experience. It was also necessary to determine formal schools represented by this category. While each school's duration is considerably longer than hours represented in the "ALT" category, estimates based on the aggregated amount of time devoted to teaching given sub-process from each school: SSDS Basic Operator Course of Instruction, SSDS Advanced Operator Course of Instruction, and SSDS Warfare Operator Course of Instruction. **b. Officer-AEGIS** Individual completing officer training with no prior AEGIS platform experience. It was also necessary to determine formal schools represented by this category. While each school's duration is considerably longer than the hours represented in the "ALT" category, estimates based on aggregated amount of time devoted to teaching the given sub-process from each school: AEGIS Training Course, SWOS TAO School, and TAO Simulator Training. **c. Enlisted-SSDS** Individual completed boot camp with no prior SSDS platform experience. It was also necessary to determine formal schools represented by this category. While each school's duration considerably longer than hours represented in the "ALT" category, estimates determined based on aggregated amount of time devoted to teaching the given sub-process from each school: OS "A" School, SSDS Basic Operator Course of Instruction, SSDS Advanced Operator Course of Instruction, and SSDS Warfare Operator Course of Instruction (E5 and above). **d. Enlisted-AEGIS** Individual completed boot camp with no prior AEGIS platform experience. It was also necessary to determine formal schools represented by this category. While each school's duration is considerably longer than hours represented in the "ALT" category, estimates based on aggregated amount of time that devoted to teaching given sub-process from each school: OS "A" School and AEGIS Console Operator Course.
Rank Order	An ordinal ranking of sub-processes provides a means to ensure the "ALT" estimates are reliable and as accurate as possible.	• Allowing SMEs to rank/order each of the sub-processes (1 being the least complex), outside the context of units of time, facilitates a mathematical correlation achieved between "Rank Order" and "ALT" categories. • If correlation is .80 or higher, "ALT" numbers can be considered an accurate reflection of the sub–process's complexity. • If correlation is below .80, "ALT" estimates should be closely scrutinized and possibly reevaluated after providing a better explanation of the "ALT" components to the SMEs.

Percent Information Technology (%IT)	Percent of automation for each sub-process.	• Captures knowledge embedded within the IT so that it can be accounted for in later calculations. Automation is defined as the amount of the sub-process that is performed by information technology systems and does not require the actions of an operator. • Each sub-process is represented by a percentage between 0 and 100. A number of 100% indicates sub-process is completely automated and does not require a watch stander to accomplish any portion of the task. • If number is 0%, no automation exists, and the watch-stander completes the entire sub-process manually. Numbers falling between extremes are estimates based on SME observations and experience.
Total Learning Time (TLT)	**Provides total time required to learn sub-process, including that learning time which is resident within the IT system.**	• Determined by "Actual Learning Time" by the "Percent Information Technology" category. • *Formula = ALT/(1-%IT).* • For instance: If it takes 2 hours to learn a system that is 50% automated, then the total learning time for that system (to include the learning time that is embedded in the system itself) would be 4 hours.
Numerator	**Revenue generated by knowledge required to perform sub-process.**	• Revenue allocated to the amount of knowledge; amount of knowledge resident in sub-process. • Formula= *"Number of Personnel" x "Actions per Hour" x "Total Learning Time"*
Denominator	**Cost associated with producing sub-process output.**	• *Formula = "Number of Personnel" X "Actions per Hour" X "Actual Work Time"*
Return on Knowledge (ROK)	Represents how well knowledge assets in organization are distributed based upon cost and value each provides.	• With every sub-process, there is a cost and revenue (or value) associated with generating an output. While these costs and values are captured in the "Numerator" and "Denominator" categories, there needs to be a way to quantify the knowledge embedded within an IT system. • ROK's can be compared within a process to help determine if knowledge assets are being used in an efficient manner; if automation could be inserted to improve outputs; and if processes should be changed to promote efficiencies. • A low ROK does not automatically assume a process is inefficient or in need of automation, but rather is an indicator that a sub-process may need further analysis to determine if it is using its knowledge assets in an efficient manner.

4. Variability Report

Average Work Time: 5% Variability—The time it takes to complete each action is relatively stable with little or no variability.

Average Learning Time: 5% Variability—Estimates regarding average learning time are based on the time it takes an average person to learn each task, hence, low variability.

Price: Assume 60% of the time the position is priced at the average of the low and high estimates. The remaining time is split 20-20 between the low and high values. A custom distribution is utilized to fulfill these requirements.

Watch Station	Cost Range (per hour)
Tactical Action Officer (TAO)	$85 to $105, $80.00 to $110.00
Anti-air Warfare Coordinator (AAWC)	$75 to $90, $72.00 to $92.00
Surface Warfare Coordinator (SUWC)	$75 to $90, $72.00 to $92.00
Combat Systems Coordinator (CSC)	$78 to $95, $69.00 to $89.00
Tactical Information Coordinator (TIC)	$70 to $80, $65.00 to $85.00
Identification Supervisor (IDS)	$70 to $80, $63.00 to $83.00

Note: Prices provided by commercial vendors.

Cost: Assumes 60% of the time the position is filled by a person with the assumed pay grade. The remaining time is split 20-20% between a person with one rank higher and one rank lower.[10] A custom distribution is utilized to fulfill these requirements.

Watch Station	Years of Service	Cost
Tactical Action Officer (TAO): (0-5)	between 10-18	$38
Anti-Air Warfare Coordinator (AAWC): (0-4)	between 8-16	$34
Surface Warfare Coordinator (SUWC): (0-3)	between 6-14	$30
Combat Systems Coordinator (CSC): (E-8)	between 10-18	$27
Tactical Information Coordinator (TIC): (E-6)	between 4-14	$17
Identification Supervisor (IDS): (E-5)	between 3-8	$14

Note: Costs calculated by averaging monthly salary plus sea pay for the assumed ranks at low/high estimates of years in service.

Actions per Hour: A triangular distribution with min/max/most-likely values based on calculations from the following numbers.

	Costal	Open Water	High Density
Number of Contacts per Hour	24-42	12-30	28-66
Time in Location	15%	25%	60%

Note: Data provided by SMEs

[10] In the case of a TAO, assume 80% of the time the position is filled by an 0-5; in the case of an IDS, assume 80% or the time the position is filled by an E-5.

Appendix B. KVA Results by Watch Station

Figure B-1. AEGIS ROI Estimates

	Tactical Action Officer				Anti-Air Warfare Coordinator				Surface Warfare Coordinator			
	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"
CORRELATE												
Obtain Link Information	3625%	3450%	3206%	2717%	5091%	4907%	4525%	3979%	2441%	2304%	2230%	2044%
Identify "Same Contact,Multiple Track"	-91%	-91%	2104%	1778%	-87%	-87%	2983%	2619%	-94%	-94%	1453%	1329%
Verify Other Track Sources	-94%	-94%	-95%	-96%	-92%	-92%	-93%	-94%	-96%	-96%	-96%	-97%
Correlate Sub-Total	***1358%***	***1290%***	***1791%***	***1512%***	***1932%***	***1860%***	***2546%***	***2233%***	***497%***	***465%***	***476%***	***431%***
TRACK												
Monitor Suspect Tracks	-98%	-99%	-99%	-99%	-98%	-98%	-98%	-98%	-99%	-99%	-99%	-99%
Update Tracks	-97%	-97%	294%	235%	-96%	-96%	451%	386%	-98%	-98%	177%	155%
Update GCCS-M	-95%	173%	154%	117%	-	-	-	-	-97%	85%	79%	65%
Track Sub-Total	***-98%***	***-97%***	***-85%***	***-87%***	***-97%***	***-97%***	***-50%***	***-56%***	***-97%***	***-55%***	***47%***	***36%***
IDENTIFY												
Verify IFF signal	645%	610%	561%	463%	938%	901%	825%	716%	408%	381%	366%	329%
Verify EW emissions	-89%	-89%	-90%	540%	-89%	-91%	-92%	827%	-92%	-93%	-93%	387%
Verify Point of Origin	-98%	3450%	3206%	2717%	-97%	4907%	4525%	3979%	-99%	2304%	2230%	2044%
Match Against ATO	-98%	3450%	3206%	2717%	-97%	4907%	4525%	3979%	-	-	-	-
Match Against CommAir Profile	831%	788%	727%	604%	1198%	1152%	1056%	920%	-	-	-	-
Match Against Intel Information	-97%	-97%	-97%	3813%	-96%	-96%	-96%	5565%	-98%	-98%	-98%	2878%
Examine Kinematic Data	-96%	-96%	-97%	-97%	-95%	-95%	-95%	-96%	-97%	-98%	-98%	-98%
Obtain Visual ID	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%
Conduct Verbal Query	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%
Identify Sub-Total	***55%***	***152%***	***134%***	***596%***	***84%***	***197%***	***174%***	***689%***	***-95%***	***-93%***	***-93%***	***-26%***
RELAY												
Send Over Links	-91%	-91%	-92%	-93%	-87%	-87%	-88%	-90%	-94%	-94%	-94%	-95%
Discuss Picture with Battle Force Units	-99%	-99%	-99%	-99%	-98%	-98%	-98%	-99%	-99%	-99%	-99%	-99%
Relay Sub-Total	***-98%***	***-100%***	***-100%***	***-100%***	***-98%***	***-98%***	***-98%***	***-98%***	***-99%***	***-100%***	***-100%***	***-100%***
TOTAL	***306%***	***347%***	***389%***	***558%***	***354%***	***400%***	***451%***	***640%***	***9%***	***13%***	***17%***	***64%***

Figure B-2. AEGIS ROI Estimates (cont.)

	Combat Systems Coordinator				Tactical Information Coordinator				Identification Supervisor			
	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"
CORRELATE												
Obtain Link Information	1040%	1034%	937%	743%	5012%	4889%	4510%	4146%	5921%	5772%	5312%	4870%
Identify "Same Contact, Multiple Track"	-97%	-97%	591%	462%	-87%	-88%	2973%	2731%	-85%	-85%	3508%	3213%
Verify Other Track Sources	-98%	-98%	-98%	-99%	-92%	-92%	-93%	-93%	-91%	-91%	-92%	-92%
Correlate Sub-Total	***346%***	***344%***	***493%***	***383%***	***1901%***	***1853%***	***2537%***	***2329%***	***2257%***	***2199%***	***2996%***	***2743%***
TRACK												
Monitor Suspect Tracks	-100%	-100%	-100%	-100%	-98%	-98%	-98%	-98%	-97%	-98%	-98%	-98%
Update Tracks	-99%	-99%	65%	34%	-96%	-96%	449%	405%	-96%	-96%	544%	492%
Update GCCS-M	-	-	-	-	-	-	-	-	-	-	-	-
Track Sub-Total	***-99%***	***-99%***	***-94%***	***-96%***	***-97%***	***-97%***	***-5%***	***-13%***	***-97%***	***-97%***	***11%***	***2%***
IDENTIFY												
Verify IFF signal	128%	127%	107%	69%	922%	898%	822%	749%	1104%	1074%	982%	894%
Verify EW emissions	-96%	-96%	-97%	113%	-85%	-85%	-86%	865%	-82%	-82%	-84%	1030%
Verify Point of Origin	-99%	1411%	1282%	1025%	-97%	4889%	4510%	4146%	-97%	5772%	5312%	4870%
Match Against ATO	-99%	1411%	1282%	1025%	-97%	4889%	4510%	4146%	-97%	5772%	5312%	4870%
Match Against CommAir Profile	280%	278%	246%	181%	1178%	1147%	1053%	962%	1405%	1368%	1253%	1142%
Match Against Intel Information	-99%	-99%	-99%	1462%	-96%	-96%	-96%	5797%	-95%	-95%	-95%	6803%
Examine Kinematic Data	-98%	-98%	-99%	-99%	-95%	-95%	-95%	-96%	-94%	-94%	-95%	-95%
Obtain Visual ID	-	-	-	-	-100%	-100%	-100%	-100%	-99%	-100%	-100%	-100%
Conduct Verbal Query	-	-	-	-	-99%	-99%	-99%	-99%	-98%	-99%	-99%	-99%
Identify Sub-Total	***-54%***	***-50%***	***-54%***	***148%***	***21%***	***69%***	***56%***	***242%***	***99%***	***182%***	***160%***	***503%***
RELAY												
Send Over Links	-96%	-96%	-97%	-97%	-87%	-88%	-88%	-89%	-85%	-85%	-86%	-88%
Discuss Picture with Battle Force Units	-	-	-	-	-98%	-98%	-98%	-99%	-98%	-98%	-98%	-98%
Relay Sub-Total	***-96%***	***-100%***	***-100%***	***-100%***	***-98%***	***-100%***	***-100%***	***-100%***	***-95%***	***-95%***	***-95%***	***-96%***
TOTAL	***54%***	***56%***	***73%***	***162%***	***228%***	***258%***	***297%***	***423%***	***298%***	***335%***	***382%***	***535%***

Figure B-3. SSDS ROI Estimates

	Tactical Action Officer				Anti-Air Warfare Coordinator				Surface Warfare Coordinator			
	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"
CORRELATE												
Obtain Link Information	2129%	2025%	1871%	1578%	3006%	2896%	2655%	2329%	1420%	1339%	1292%	1181%
Identify "Same Contact, Multiple Track"	-94%	-95%	1477%	1243%	-92%	-93%	2104%	1843%	-96%	-96%	1013%	925%
Verify Other Track Sources	-97%	-97%	-97%	-97%	-95%	-95%	-96%	-96%	-98%	-98%	-98%	-98%
Correlate Sub-Total	***773%***	***732%***	***1045%***	***876%***	***1116%***	***1073%***	***1502%***	***1312%***	***257%***	***238%***	***245%***	***217%***
TRACK												
Monitor Suspect Tracks	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%
Update Tracks	-98%	-98%	182%	140%	-98%	-98%	294%	247%	-99%	-99%	99%	83%
Update GCCS-M	-97%	63%	52%	29%	-	-	-	-	-98%	11%	7%	-1%
Track Sub-Total	***-99%***	***-98%***	***-91%***	***-92%***	***-98%***	***-98%***	***-70%***	***-73%***	***-98%***	***-73%***	***-8%***	***-15%***
IDENTIFY												
Verify IFF signal	346%	325%	294%	236%	521%	499%	451%	386%	204%	188%	178%	156%
Verify EW emissions	-93%	-94%	-94%	281%	-91%	-91%	-92%	452%	-95%	-96%	-96%	191%
Verify Point of Origin	-99%	2025%	1871%	1578%	-98%	2896%	2655%	2329%	-99%	1339%	1292%	1181%
Match Against ATO	-99%	2025%	1871%	1578%	-98%	2896%	2655%	2329%	-	-	-	-
Match Against CommAir Profile	457%	431%	393%	320%	677%	649%	589%	507%	-	-	-	-
Match Against Intel Information	-98%	-98%	-98%	2231%	-97%	-98%	-98%	3273%	-99%	-99%	-99%	1679%
Examine Kinematic Data	-98%	-98%	-98%	-98%	-97%	-97%	-97%	-98%	-98%	-99%	-99%	-99%
Obtain Visual ID	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%
Conduct Verbal Query	-99%	-99%	-100%	-100%	-99%	-99%	-99%	-99%	-100%	-100%	-100%	-100%
Identify Sub-Total	***-7%***	***51%***	***40%***	***314%***	***10%***	***78%***	***64%***	***370%***	***-97%***	***-96%***	***-96%***	***-56%***
RELAY												
Send Over Links	-94%	-95%	-95%	-96%	-92%	-93%	-93%	-94%	-96%	-96%	-97%	-97%
Discuss Picture with Battle Force Units	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-100%	-100%	-100%
Relay Sub-Total	***-99%***	***-100%***	***-100%***	***-100%***	***-99%***	***-99%***	***-99%***	***-99%***	***-99%***	***-100%***	***-100%***	***-100%***
TOTAL	***143%***	***168%***	***193%***	***294%***	***172%***	***199%***	***230%***	***343%***	***-35%***	***-33%***	***-30%***	***-2%***

Figure B-4. SSDS ROI Estimates (cont.)

	Combat Systems Coordinator				Tactical Information Coordinator				Identification Supervisor			
	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"	"AS IS"	"TO BE"	"RAD 1"	" RAD 2"
CORRELATE												
Obtain Link Information	2628%	2613%	2370%	1907%	9076%	8856%	8141%	7487%	10708%	10441%	9572%	8779%
Identify "Same Contact, Multiple Track"	-93%	-93%	1876%	1505%	-77%	-78%	6492%	5970%	-73%	-74%	7638%	7003%
Verify Other Track Sources	-96%	-96%	-96%	-97%	-86%	-86%	-87%	-88%	-83%	-84%	-85%	-86%
Correlate Sub-Total	***968%***	***962%***	***1336%***	***1066%***	***3492%***	***3406%***	***4690%***	***4310%%***	***4131%***	***4027%***	***5522%***	***5061%***
TRACK												
Monitor Suspect Tracks	-99%	-99%	-99%	-99%	-96%	-96%	-97%	-97%	-95%	-96%	-96%	-96%
Update Tracks	-98%	-98%	253%	187%	-93%	-94%	1077%	984%	-92%	-92%	1282%	1168%
Update GCCS-M	-	-	-	-	-	-	-	-	-	-	-	-
Track Sub-Total	***-99%***	***-99%***	***-90%***	***-92%***	***-95%***	***-95%***	***75%***	***61%***	***-94%***	***-94%***	***105%***	***88%***
IDENTIFY												
Verify IFF signal	446%	443%	394%	301%	1735%	1691%	1548%	1417%	2062%	2008%	1834%	1676%
Verify EW emissions	-92%	-92%	-93%	356%	-72%	-73%	-75%	1624%	-68%	-68%	-71%	1918%
Verify Point of Origin	-99%	2613%	2370%	1907%	-95%	8856%	8141%	7487%	-95%	10441%	9572%	8779%
Match Against ATO	-99%	2613%	2370%	1907%	-95%	8856%	8141%	7487%	-95%	10441%	9572%	8779%
Match Against CommAir Profile	582%	578%	517%	402%	2194%	2139%	1960%	1797%	2602%	2535%	2318%	2120%
Match Against Intel Information	-98%	-98%	-98%	2687%	-92%	-93%	-93%	10437%	-91%	-91%	-92%	12231%
Examine Kinematic Data	-97%	-97%	-98%	-98%	-91%	-91%	-92%	-92%	-89%	-89%	-90%	-91%
Obtain Visual ID	-	-	-	-	-99%	-99%	-99%	-99%	-99%	-99%	-99%	-99%
Conduct Verbal Query	-	-	-	-	-98%	-98%	-98%	-98%	-97%	-97%	-98%	-98%
Identify Sub-Total	***-17%***	***-9%***	***-17%***	***346%***	***118%***	***203%***	***179%***	***512%***	***257%***	***406%***	***364%***	***977%***
RELAY												
Send Over Links	-93%	-93%	-94%	-95%	-77%	-78%	-79%	-81%	-73%	-74%	-76%	-78%
Discuss Picture with Battle Force Units	-	-	-	-	-97%	-97%	-97%	-97%	-96%	-96%	-97%	-97%
Relay Sub-Total	***-93%***	***-100%***	***-100%***	***-100%***	***-96%***	***-100%***	***-100%***	***-100%***	***-91%***	***-91%***	***-92%***	***-92%***
TOTAL	***256%***	***260%***	***300%***	***459%***	***489%***	***544%***	***613%***	***839%***	***615%***	***682%***	***766%***	***1040%***

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Appendix C. Real Options Analysis

Table C-2. KVA Analysis with Monte Carlo risk-based simulations

Billet	Contact ID Subprocess	Number of Personnel	ApH Min	Actions per Hour	APH ADD	APH REP	ApH Max	-5%	AWT (Hours)	5%	-5%	ALT (Hours)	5%	NLT
Tactical Action Officer (TAO)	**CORRELATE**													
	Obtain Link Information	1	64	256	256	256	332.8	0.0016	0.00164	0.0017	7.6	8.0	8.4	2.0
	Identify "Same Contact, Multiple Track"	1	10	40	70	160	52	0.0016	0.00166	0.0017	7.6	8.0	8.4	1.0
	Verify Other Track Sources	1	5	20	20	20	26	0.0156	0.01647	0.0173	9.5	10.0	10.5	3.0
	TRACK													
	Monitor Suspect Tracks	1	6.25	25	25	25	32.5	0.0230	0.02426	0.0255	3.8	4.0	4.2	3.0
	Update Tracks	1	2.5	10	16.5	28.57143	13	0.0016	0.00170	0.0018	1.9	2.0	2.1	2.0
	Update GCCS-M	1	0.5	2	2.7	3.076923	2.6	0.0015	0.00163	0.0017	1.9	2.0	2.1	1.0
	IDENTIFY													
	Verify IFF signal	1	32	128	128	128	166.4	0.0016	0.00173	0.0018	7.6	8.0	8.4	8.0
	Verify EW emissions	1	6.25	25	25	25	32.5	0.0083	0.00869	0.0091	5.7	6.0	6.3	5.0
	Verify Point of Origin	1	3	12	23.4	240	15.6	0.0015	0.00159	0.0017	1.9	2.0	2.1	3.0
	Match Against ATO	1	5	20	39	400	26	0.0015	0.00162	0.0017	1.9	2.0	2.1	6.0
	Match Against CommAir Profile	1	32	128	128	128	166.4	0.0016	0.00167	0.0018	1.9	2.0	2.1	4.0
	Match Against Intel Information	1	6.25	25	25	25	32.5	0.0238	0.02509	0.0263	9.5	10.0	10.5	9.0
	Examine Kinematic Data	1	6.25	25	25	25	32.5	0.0160	0.01686	0.0177	3.8	4.0	4.2	7.0
	Obtain Visual ID	1												
	Conduct Verbal Query	1												
	RELAY													
	Send Over Links	1												
	Discuss Picture with Battle Force Units	1												
	Totals													
Anti Air Warfare Coordinator	**CORRELATE**													
	Obtain Link Information	1												
	Identify "Same Contact, Multiple Track"	1												
	Verify Other Track Sources	1												
	TRACK													
	Monitor Suspect Tracks	1												
	Update Tracks	1												
	Update GCCS-M	0												
	IDENTIFY													
	Verify IFF signal	1	32	128	128	128	166.4	0.0016	0.00167	0.0018	7.6	8.0	8.4	8.0
	Verify EW emissions	1	6.25	25	25	25	32.5	0.0079	0.00833	0.0088	5.7	6.0	6.3	5.0
	Verify Point of Origin	1	3	12	23.4	240	15.6	0.0016	0.00167	0.0018	1.9	2.0	2.1	3.0
	Match Against ATO	1	5	20	39	400	26	0.0016	0.00167	0.0018	1.9	2.0	2.1	6.0
	Match Against CommAir Profile	1	32	128	128	128	166.4	0.0016	0.00167	0.0018	1.9	2.0	2.1	4.0
	Match Against Intel Information	1	6.25	25	25	25	32.5	0.0238	0.02500	0.0263	9.5	10.0	10.5	9.0

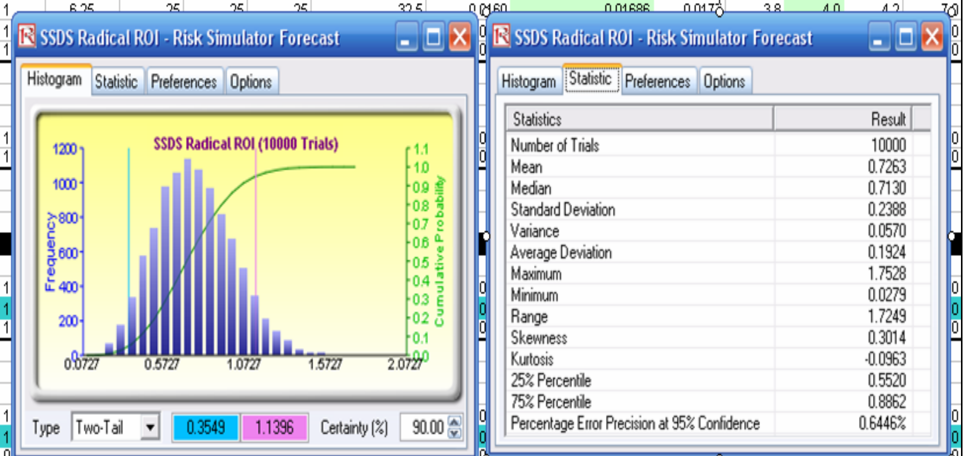


Table C-3. Strategy B: Real Options Analysis Results

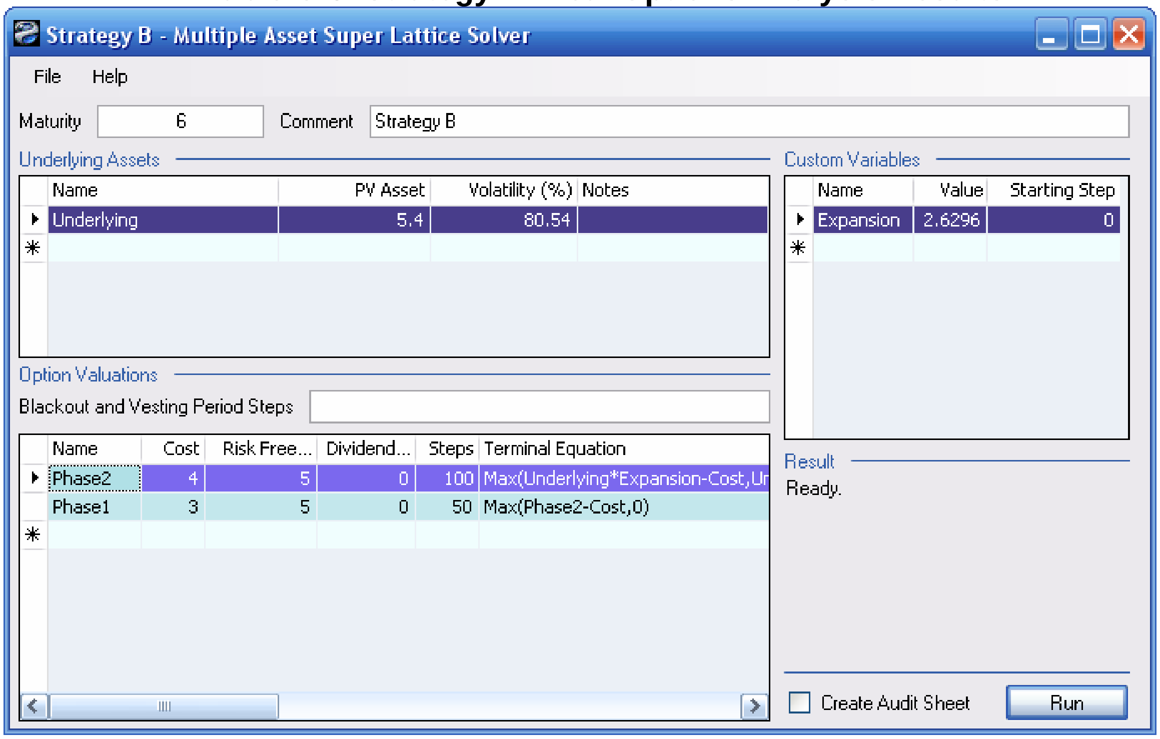
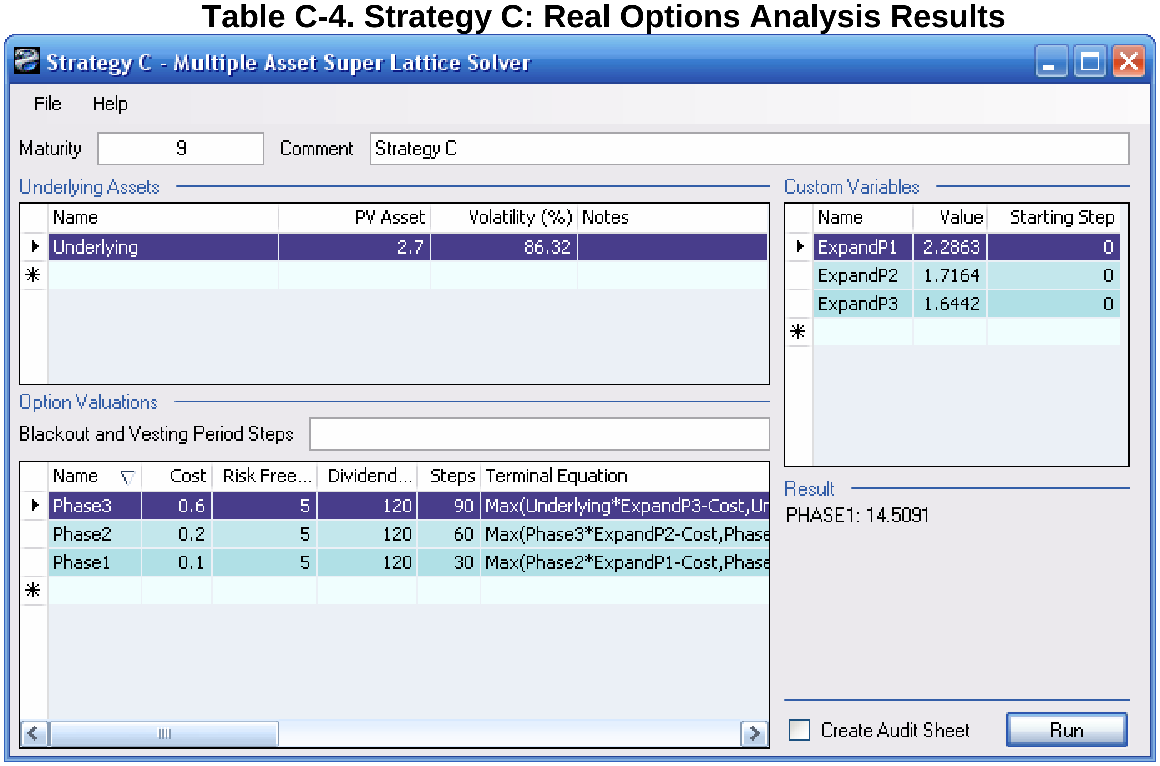


Table C-4. Strategy C: Real Options Analysis Results



References

Mullen, M., Admiral. (2006, August 28). *Memorandum for Assistant Secretary of the Navy for Research, Development, and Acquisition.* Washington, DC: ASN (R&D, A).

Fein, G. (2006, September 11). CNO looks to speed up pace of "disappointing" move to open architecture. *Defense Daily*.

Government Accountability Office. (2004, March). *Stronger management practices are needed to improve DoD's software-intensive weapon acquisitions.* Washington, DC. GAO Report GAO-04-393, p.4

Government Accountability Office. (2006, January). *DOD management approach and processes not well-suited to support development of global information grid.* Washington, DC. GAO Report GAO-06-211, p.6.

IBM. (2005, January 11). *IBM pledges 500 US patents to open source in support of innovation and open standards.* IBM Press Release, <http://www-03.ibm.com/press/us/en/pressrelease/7473.wss> [September 21, 2006]

CDN Staff(2006, August 16), *IT Business*, "The Real Impact of Open Source," <http://www.itbusiness.ca/it/client/en/EDGE/News.asp?id=40328> [September 22, 2006]

Komoroski, C., Housel, T., Hom, S., & Mun, J. (2006, October). *A methodology for improving the shipyard planning process: Using KVA analysis, risk simulation and strategic real options*. Sponsored Report Series. Monterey, CA: Naval Postgraduate School.

Herz, J.C., Lucas, M., &, Scott, J.(2006, April), *Open Technology Roadmap*, p.5, <http://www.acq.osd.mil/actd/articles/OTDRoadmapFinal.pdf> [September 20, 2006]

Oracle Corporation. (2004), *Oracle Application Server 10g-Application Platform Suite*, <http://www.oracle.com/appserver/docs/aps.pdf>, [December 18, 2006]

OSI (2006). <http://www.opensource.org/licenses/> [September 21, 2006]

Payton, S. (2006, August 14). Write as we fight. *Military Information Technology*, 10(7)., <http://www.military-information-technology.com/article.cfm?DocID=1589> [September 22, 2006]

Perez, J.C. (2006, March 6). AOL opens AIM service to external developers. *Network World*, <http://www.infoworld.com/article/06/03/06/76123_HNaolopensaim_1.html> [September 21, 2006]

Strei, T.J. (2003, April 1). Open architecture in naval combat system computing of the 21st century, p. 5..

Uchytil. (2006, June). Assessing the operational value of situational awareness for AEGIS and SSDS platforms through the application of Knowledge Value Added (KVA) methodology.

Wait, P. (2006, July 3). Weapons projects misfire on software. *Government Computer News*., <http://www.gcn.com/print/25_18/41177-1.html> [September 21, 2006]

------ Navy Visibility and Management of Operating and Support Costs, <http://www.navyvamosc.com> [October 1, 2006]

---- AEGIS Weapons System MK-7, <http://www.globalsecurity.org/military/systems/ship/systems/aegis.htm> [September 28, 2006]

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